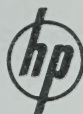


HEWLETT-PACKARD

200CD

WIDE RANGE OSCILLATOR

OPERATING AND SERVICING MANUAL



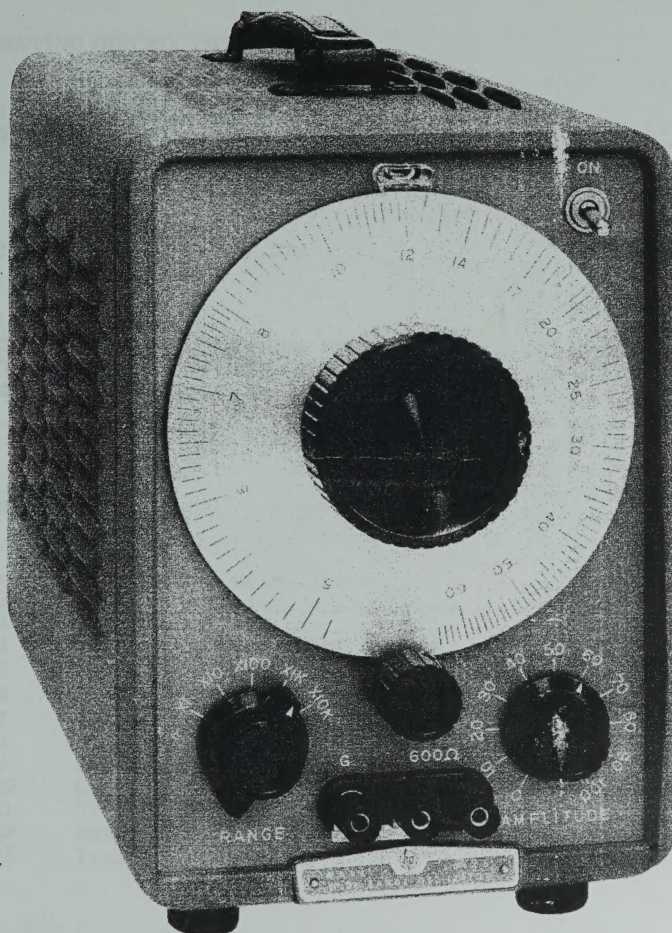
OPERATING AND SERVICING MANUAL

FOR

MODEL 200CD/CDR

WIDE RANGE OSCILLATOR

SERIAL 8739 AND ABOVE



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275 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

200C001-4

CONTENTS

SECTION I GENERAL DESCRIPTION

1 - 1	General Description	I - 1
1 - 2	Power Cable	I - 1
1 - 3	230 Volt Operation	I - 1
1 - 4	Inspection	I - 1

SECTION II OPERATING INSTRUCTIONS

2 - 1	Operating Procedure	II - 1
2 - 2	Output Circuit Options	II - 1

SECTION III CIRCUIT DESCRIPTION

3 - 1	General	III - 1
3 - 2	Frequency-Controlling Bridge	III - 1
3 - 3	Amplifier	III - 2
3 - 4	Output Circuit	III - 2

SECTION IV MAINTENANCE

4 - 1	General	IV - 1
4 - 2	Cover Removal	IV - 1
4 - 3	Tube Replacement	IV - 1
4 - 4	Replacement of Lamps R13 and R14	IV - 1
4 - 5	Replacement of Electrolytic Capacitors	IV - 2
4 - 6	Replacement of Variable Resistors and Capacitors	IV - 2
4 - 7	Lubrication, Tuning-Capacitor Drive Mechanism	IV - 2
4 - 8	Check for Cause of Distortion	IV - 2
4 - 9	Replacement of Range Switch	IV - 2
4 - 10	Calibration	IV - 2
4 - 11	Tracking Adjustments	IV - 3
4 - 12	Power Transformer Primary Connections	IV - 4
4 - 13	Trouble Shooting Chart	IV - 5

SECTION V TABLE OF REPLACEABLE PARTS

5 - 1	Table of Replaceable Parts	V - 1
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SPECIFICATIONS

FREQUENCY RANGE:	5 cps to 600 kc covered in five ranges.		
RANGES:	X1	5 cps to	60 cps
	X10	50 cps to	600 cps
	X100	500 cps to	6 kc
	X1,000	5 kc to	60 kc
	X10,000	50 kc to	600 kc
ACCURACY:	$\pm 2\%$ including calibration error, warm-up, changes due to aging of components, tubes, etc.		
DIAL:	Six inch diameter calibrated over 300° of arc. 85 divisions. Total scale length, 78 inches.		
FREQUENCY RESPONSE:	± 1 db entire frequency range (reference 1 kc).		
OUTPUT:	160 milliwatts (10 volts) into 600 ohm rated load, 20 volts open circuit.		
OUTPUT BALANCE:	Better than .1% at lower frequencies and approximately 1% at higher frequencies.		
INTERNAL IMPEDANCE:	600 ohms. Output is balanced to ground for zero position of output attenuator. (May be operated with one side grounded if desired.)		
DISTORTION:	Less than 0.5% below 500 KC; less than 1% 500 KC and above. Independent of load impedance.		
HUM VOLTAGE:	Less than 0.1% of rated output. Decreases as output is attenuated.		
POWER:	115/230 volts, $\pm 10\%$, 50/1000 cps, 75 watts.		
ACCESSORIES AVAILABLE:	<p>Ⓢ AC-60A Line Matching Transformer, 5 to 600 kc (provides balanced output at any attenuator setting at 135 and 600-ohms).</p> <p>Ⓢ AC-16A Cable Assembly, 44" RG-58/U Cable terminated each end with dual banana jack plugs.</p>		
DIMENSIONS:	<p>Cabinet Mount: 7-1/2" wide, 11-1/2" high, 14-1/4" deep.</p> <p>Rack Mount: 19" wide, 7" high, 14-1/4" deep, depth behind panel 13".</p>		
WEIGHT:	<p>Cabinet Mount: 23 lbs., shipping weight approximately 29 lbs.</p> <p>Rack Mount: 27 lbs., shipping weight approximately 35 lbs.</p>		

SECTION I

GENERAL DESCRIPTION

1-1 GENERAL DESCRIPTION

The Model 200CD Wide Range Oscillator generates frequencies of excellent waveform in the subsonic, audio, and supersonic ranges (5 cycles to 600 kc, in five overlapping decade bands). The Model 200CD includes new design features which result in still finer performance than previous ϕ instruments. Special circuitry ensures an output voltage of low distortion and high stability with any output load impedance from zero ohms to open circuit. Usefulness of the oscillator has been extended by designing the 200CD output circuit so that the instrument may be operated balanced as well as unbalanced and by providing a 600-ohm impedance match.

The Model 200CD is easy to operate: frequency and amplitude of the output voltage are set merely by operating dials on the control panel. The easily-read, six-inch diameter frequency dial is calibrated over 300° of arc, and has an effective scale length of approximately 80 inches.

The Model 200CD furnishes up to 10 volts into a 600-ohm load (20 volts open circuit) at any frequency from 5 cps to 600 kc. A bridged tee variable attenuator in the output circuit controls the output power.

The Model 200CD provides an ideal signal source for testing servo and vibrating systems, medical and geophysical equipment, audio amplifier circuits and transducers, sonar and supersonic apparatus, carrier telephone systems, video frequency circuits, and low radio-frequency equipment.

1-2 POWER CABLE

The three-conductor power cable supplied with this instrument is terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin added to a standard two blade connector which grounds the instrument chassis when used with an appropriate receptacle. To use this connector in a two-contact receptacle, a three-prong to two-prong adapter should be used. When the adapter is used the third contact is terminated in a short lead from the adapter which can then be connected to the outlet mounting box in order to ground the instrument chassis.

1-3 230-VOLT OPERATION

This instrument is normally wired for operation from a nominal 115 volt supply. Operation from a 230 volt source is easily accomplished by reconnecting the dual primary windings on the power transformer in series. Refer to the schematic drawing for the proper connections. Replace the 1 ampere slow blow fuse with a 1/2 ampere slow blow fuse.

1-4 INSPECTION

This instrument was thoroughly tested and inspected before being shipped, and is ready for use when received.

After the instrument is unpacked, it should be inspected carefully for damage received in transit. If any shipping damage is found, follow the procedure outlined in the "Claim for Damage in Shipment" page of this instruction book.

GLOWS WHEN INSTRUMENT IS ENERGIZED.

FUSE ON REAR OF INSTRUMENT, 1 AMPERE SLOW-BLOW FOR 115 V OPERATION.

READ FREQUENCY OF OPERATION MULTIPLIED BY RANGE-SWITCH POSITION.

TURN ON POWER TO INSTRUMENT.

VERNIER, ADJUST FREQUENCY.

SELECT FREQUENCY RANGE OF OPERATION.

ADJUST OUTPUT VOLTAGE LEVEL. OUTPUT BALANCED TO GROUND ONLY WITH AMPLITUDE CONTROL IN FULL CLOCKWISE POSITION.

JUMPER FOR 600 Ω UNBALANCED OUTPUT.

BALANCED OUTPUT TERMINALS INTERNAL $Z = 600\Omega$

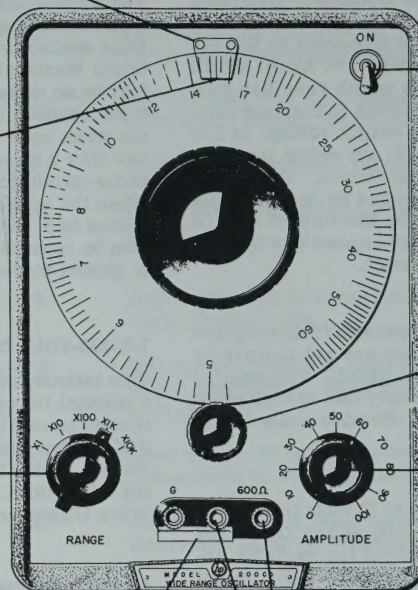


Figure 2-1 Controls and Terminals

SECTION II

OPERATING INSTRUCTIONS

2-1 OPERATING PROCEDURE

- a. With the instrument plugged into a power source of specified voltage and frequency, and the power switch at ON, allow a warm-up period of approximately five minutes. Where maximum accuracy is desired, this warm-up period should be extended at least to thirty minutes.

NOTE

If a 230-volt power source is used, check (1) that power transformer T3 is strapped for 230-volt operation (strapping options are shown on the schematic diagram), and (2) that fuse F1 is a 1/2 ampere Slo-Blo fuse. See paragraph 4-12.

- b. The frequency of the output voltage is determined (1) by the setting of the frequency dial and (2) by the setting of the RANGE switch. For example, to obtain a 1,000-cycle output, set the frequency dial at 10 and the RANGE switch at X100 (10 x 100 is 1,000).

- c. Turn the AMPLITUDE control to the zero position. Make the connection between the Model 200CD and the equipment to be driven at the terminals designated 600Ω. (Connections are discussed in paragraph 2-2.)

The Model 200CD may be operated into a load of any value without effect on the output waveform. Loads of less than 600 ohms will decrease the maximum available output voltage, and loads of more than 600 ohms will increase the available output voltage. The Model 200CD may be considered as a 20-volt generator with a 600-ohm internal impedance.

- d. Adjust the AMPLITUDE control to obtain the desired level of output voltage.

2-2 OUTPUT CIRCUIT OPTIONS

The output circuit of the Model 200CD may be arranged for balanced or unbalanced operation. Typical connections for each are indicated in Figure 2-2.

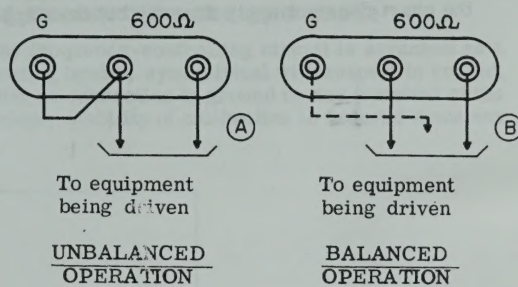


Figure 2-2. Model 200CD
Typical Output Connections

UNBALANCED OPERATION

To operate with one side grounded, a strap is placed between the G terminal and the center terminal, as indicated in Figure 2-2A.

BALANCED OPERATION

Connections for balanced operation are indicated in Figure 2-2B. (The broken line from the ground terminal indicates the output circuit is balanced to ground, within the tolerances given below.)

The AMPLITUDE control in the output circuit is a bridged tee attenuator and at any setting except minimum attenuation unbalances the circuit. Therefore, for balanced operation the AMPLITUDE control must be set for maximum output (full cw). Output balance

also is a function of frequency because of capacitive feed-through at higher frequencies. Up to 10 kc, however, unbalance is less than 0.1%, and at 600 kc is approximately 1%. If small outputs are desired, or if balance at higher frequencies is critical, turn the AMPLITUDE control maximum clockwise, and connect an external attenuator, designed for the frequencies involved, between the Model 200CD and the load.

A balanced output may also be obtained over the full range of the AMPLITUDE control by using an AC-60A/B Line Matching Transformer at the output terminals of the oscillator.

The following chart indicates the area where within 1% of balance may be obtained. This chart indicates balance obtainable at various settings of the AMPLITUDE control when operating into a 600-ohm load. Where other values of load are used, the chart does not apply directly but does apply for

settings of the AMPLITUDE control that would produce the indicated voltage across a 600-ohm load.

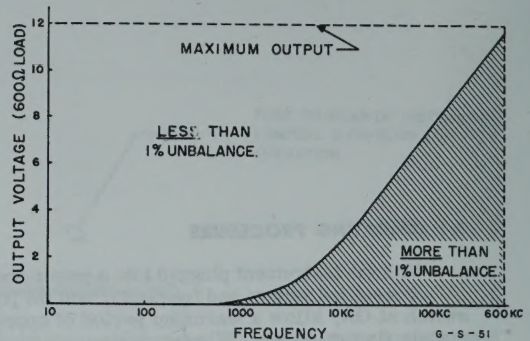


Figure 2-3. Model 200CD
Balance Chart Operating into 600-ohm Load

SECTION III

THEORY OF OPERATION

3-1 GENERAL

The Model 200CD Wide Range Oscillator uses a balanced (push-pull) oscillator circuit from which the output is taken directly, avoiding the complication and possible distortion of an isolating amplifier. Reaction of the load on the oscillator is avoided by the use of a zero source impedance output stage. This arrangement results in a simple, trouble-free circuit having low distortion and high stability over the entire frequency range.

Functionally, the circuits of the Model 200CD include a frequency-controlling bridge and balanced push-

pull amplifier which constitute the oscillator circuit, an output circuit which may be arranged either for balanced or unbalanced operation, and a power-supply circuit. These are shown in block diagram form in Figure 3-1 and in detail in the schematic diagram.

3-2 FREQUENCY-CONTROLLING BRIDGE

The frequency-controlling circuit is arranged as a floating bridge, symmetrical with respect to ground. With no connection to ground on any terminal of the bridge, stability of calibration is assured since any

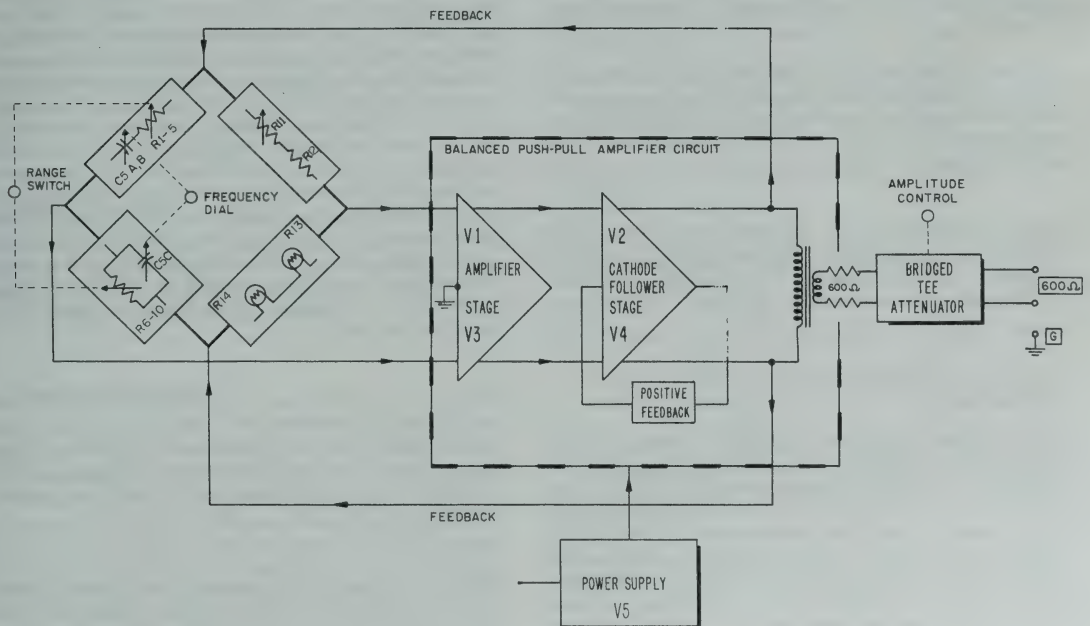


Figure 3-1. Model 200CD Block Diagram

stray capacity and leakage to ground present at the bridge output terminals do not shunt either the frequency-controlling or amplitude-stabilizing arms of the bridge. The frequency-controlling components (RC networks which are varied by operation of the RANGE switch and frequency dial) comprise two arms of the bridge, while the amplitude-stabilizing components (a voltage divider which includes a thermally-sensitive resistance) comprise the other two arms. The amplitude is stabilized at such a level that the amplifier tubes are operated in the substantially linear portion of their characteristics, which, together with the large negative feedback at harmonic frequencies, results in a very pure sine wave oscillation.

The bridge is fed by the balanced voltage developed at the cathodes of V2 and V4 in the output of the balanced amplifier. The output of the frequency-controlling branch of the bridge is applied to the grid of V3 and the output of the amplitude-stabilizing branch is applied to the grid of V1. The manner in which the voltage - versus - frequency and phase - versus - frequency characteristics of an RC network can be utilized with an amplifier of proper design to achieve an oscillator which delivers a voltage of excellent stability and waveform is well covered in texts such as Terman & Pettit's Electronic Measurements.

Variable resistor R11 is provided for adjustment of the amplitude-stabilizing branch of the bridge should it be found after replacement of lamp R13 or R14 that less or more than rated voltage is being delivered to the output terminals.

Variable capacitors C3, C6, and C7 are adjusted at the factory for optimum calibration and amplitude constancy with frequency. They should not require adjustment unless the RANGE switch is replaced.

3-3 AMPLIFIER

The oscillator amplifier is a balanced push-pull circuit which includes a voltage-amplifier stage (V1, V3) and a special cathode-follower stage (V2, V4). Criss-cross positive feedback is used in the cathode-follower stage to provide an essentially zero output impedance as seen by the cathode-to-cathode load. The feedback paths are from the plate of V2 to the control grid and screen of V4, and from the plate of V4 to the control grid and screen of V2. The degree of the positive feedback is a function of the load and increases as the load impedance decreases, thus tending to maintain the output constant regardless of load. Self-oscillation in the amplifier circuit

is prevented by proper choice of resistance in the feedback circuits and by controlling plate and cathode impedances over the entire frequency range of the oscillator. The output stage is protected against a cathode-to-cathode short circuit by the resistors in series with the transformer secondaries. These resistors also make the oscillator present a 600-ohm impedance to the attenuator.

The output stage has sufficient reserve current capacity to avoid overload even if the output terminals are shorted. Capacitors C10, C11, and C12, and coils L2 and L3 are part of the frequency-compensating circuitry.

The output from the cathode-follower stage (1) returns feedback to the frequency-controlling bridge and (2) supplies the primary winding of the output transformers, which couple the oscillator output to the output circuit.

3-4 OUTPUT CIRCUIT

Transformer coupling provides isolation between the oscillator circuit and the output circuit, and allows the output to be obtained either balanced or unbalanced. Since a single transformer will operate suitably over only a part of the frequency range covered by the 200CD, two transformers are provided. Connections between cathode-followers V2 and V4 and the proper transformer for the band in use are set up by the RANGE switch. The secondary windings of the coupling transformers supply a conventional bridged tee attenuator, the setting of which is adjusted by operation of the AMPLITUDE control on the front panel. As the control is turned counter-clockwise, the loss inserted by the attenuator is increased. The source impedance at the output terminals is 600 ohms.

With the attenuator set for minimum loss, the output circuit is arranged for balanced operation, and is so designed that for frequencies up to 10 kc, stray capacity and leakage resistance will cause less than 0.1% unbalance. Unbalance at 600 kc is approximately 1%.

When it is desired to operate unbalanced, ground should be connected to the center output terminal, the termination for the connection brought out from terminal 6 of output transformers T1 and T2. Proper operation cannot be obtained if the ground is connected to the side of the circuit which includes the attenuator.

SECTION IV MAINTENANCE

4-1 GENERAL

The maintenance data provided in this section assumes that maintenance personnel are thoroughly familiar with the operating procedures and circuit theory given in Sections II and III, respectively.

The Model 200CD Wide Range Oscillator is designed for long component life and it is probable that tube replacement will correct a majority of the difficulties which may develop. Tube replacement instructions are given in paragraph 4-3.

As a guide in tracing the cause of substandard operation, a trouble-shooting chart is provided in paragraph 4-13.

After locating the source and eliminating the cause of the trouble, the instrument should be tested and adjusted. Performance specifications are given at the front of this manual.

4-2 COVER REMOVAL

On both cabinet and rack models, the cover is fastened to the chassis at the rear with two screws. To remove the cover, remove the screws, and slide the cover off the rear of the instrument.

4-3 TUBE REPLACEMENT

OSCILLATOR

If V1, V2, V3, or V4 is replaced, distortion measurements should be made to determine that distortion in the 200CD output voltage does not exceed the rated 0.5% below 500 kc; less than 1% above 500 kc. Distortion at audio frequencies may be measured with an instrument which directly indicates percent of distortion, such as a Hewlett-Packard Model 330B Noise and Distortion Analyzer.

To determine and correct the probable cause of the distortion, refer to paragraph 4-8.

POWER SUPPLY

Rectifier tube V5 may be replaced with any tube which has corresponding RETMA standard characteristics.

4-4 REPLACEMENT OF LAMPS R13 AND R14

Since lamps R13 and R14 are operated well below rating, they should have an infinite life. However, severe mechanical vibration can damage the lamps.

To check lamp operation, measure the level of the output voltage. It should be 24 volts open circuit or 12 volts into 600 ohms. A vacuum tube voltmeter, such as a Hewlett-Packard Model 410B High Frequency Vacuum Tube Voltmeter, is suitable for making the measurement. Proceed as follows:

- Set the Model 200CD on any one of the upper ranges for any frequency above 60 cps; permit a warm-up period of about five minutes.
- Turn the AMPLITUDE control maximum clockwise.
- Connect the voltmeter to the 600 Ω terminals. The voltmeter indication should be 24 volts open circuit.

If the output voltage is not at the correct level:

- Adjust variable resistor R11 (Figure 4-2) to obtain 24 volts.

The screwdriver adjustment for R11 is brought out to the upper side of the deck, and is accessible through the top of the instrument when the cover is off.

- If a 24-volt output cannot be obtained by adjustment of R11, replace either or both lamps R13 and R14.

After replacement of the lamps, adjust R11 to obtain 24 volts open circuit.

4-5 REPLACEMENT OF ELECTROLYTIC CAPACITORS

The electrolytic capacitors in this instrument are high quality units which have a useful life of from five to ten years.

4-6 REPLACEMENT OF VARIABLE RESISTORS AND CAPACITORS

VARIABLE RESISTOR R11

After replacement of R11, the level of the output voltage should be measured (see para. 4-4, above), and R11 should be adjusted to obtain an output of 24 volts open circuit or 12 volts across 600 ohms.

VARIABLE RESISTOR R39

Replacement instructions for variable resistor R39 (AMPLITUDE control) are supplied with the replacement control.

VARIABLE CAPACITORS

Variable capacitors C3 and C6 are located on the top of tuning capacitor C5 (Figure 4-2), and variable capacitor C7 is located on the under side of the deck (Figure 4-3).

After replacement of any one of the variable capacitors, check the calibration, paragraph 4-10.

4-7 LUBRICATION, TUNING-CAPACITOR DRIVE MECHANISM

The tuning-capacitor drive mechanism should be lubricated once or twice a year, the interval depending on the amount of use. One drop of light machine oil in each of the holes in the three bearing projections on the back of the casting is sufficient.

4-8 CHECK FOR CAUSE OF DISTORTION

GENERAL

To check for the cause of distortion, the d-c voltage between the cathodes of V2 and V4 should be measured. There should be less than 1 volt between the V2-V4 cathodes, and the voltage read with the RANGE switch on X100 should be the same as that read with the switch on X10. A 20,000 ohms-per-volt, or better (such as a Hewlett-Packard Model 410B), voltmeter may be used for making the measurements. Proceed as follows:

- a. Set the RANGE switch on X10. Turn the frequency dial to "20".

- b. Allow a five minute warm-up period before making the voltage measurements. Connect one terminal of the voltmeter to pin 3 of V2 and the other to pin 3 of V4.

EXCESSIVE GRID CURRENT IN V3

- a. Note the voltmeter reading with the RANGE switch on X10.

- b. Set the RANGE switch on X100, and note the meter reading; if it differs from that obtained with the switch on X10, excessive grid current in V3 is indicated.

- 1) Before replacing V3 with a new 6SH7, interchange V1 and V3, and again measure the voltage between the V2-V4 cathodes with the RANGE switch on X10 and X100.

- 2) If the V1-V3 interchange has not corrected the trouble, replace V3 with another 6SH7.

To determine whether the replacement 6SH7 has the proper characteristics for the oscillator circuit, again measure the distortion.

BAD TUBE IN OSCILLATOR

If more than 1 volt is measured between the V2-V4 cathodes, a bad tube in the oscillator is indicated.

To determine which tube is not operating properly, substitute another tube of corresponding RETMA standard characteristics for each tube in turn. After each tube substitution, measure the distortion.

NOTE

It is recommended that substitution be made first for V1 or V3 since the characteristics of these tubes more greatly affect the purity of the output voltage than do the characteristics of V2 and V4.

4-9 REPLACEMENT OF RANGE SWITCH

GENERAL

The Model 200CD RANGE switch can be replaced as a unit. The replacement is supplied with all the necessary instructions.

4-10 CALIBRATION

The 200CD calibration can be checked and adjusted at any time. A list of equipment and a recommended procedure follows:

EQUIPMENT REQUIRED

- a. Average-responding vacuum tube voltmeter capable of reading down to at least 10 cps, such as Hewlett-Packard Models 400D, 400H, or 400L.
- b. Alignment tool (insulated screwdriver).
- c. A frequency-measuring device:
 - 1) Secondary frequency standard with comparison facilities, such as a Hewlett-Packard Model 100D Secondary Frequency Standard. (If a larger scope pattern than provided by the Model 100D is desired, an external oscilloscope may be used with the Model 100D.) Or:
- d. Frequency counter covering the range up to 600 kc, such as a Hewlett-Packard Model 523B or 524B Electronic Counter.

TERMINOLOGY

When the following expressions are used in this text, they have the meaning here specified.

Slip The Dial:

- 1) Remove center knob on frequency dial.
- 2) Loosen four screws which secure dial plate to drive shaft.
- 3) Reset dial to position indicated in text.
- 4) Tighten four securing screws. (Center knob may be replaced at end of procedure.)

On Calibration:

Frequency indication centered beneath dial indicator index is the same as output frequency.

CONNECTIONS

Connection arrangements are indicated in Figure 4-1. Connect as follows:

- a. 600-ohm load across Model 200CD output.
- b. Output of Model 200CD to input of measuring equipment.

CALIBRATION PROCEDURE

- a. Turn on Model 200CD; allow at least 30 minute warm-up period. Remove cover from Model 200CD.
- b. Set RANGE switch on X10. Turn dial to "5".
 - 1) If Model 200CD not on calibration at "5", slip dial, and put "5" on calibration.

2) Set voltage reference, for example 9 volts. (Adjust AMPLITUDE control to get voltmeter indication of 9 volts.)

- c. Turn frequency dial toward high end to find where 600 cps falls at top of X10 range. If 600 cps on X10 range does not fall at "60":
 - 1) Turn dial to "60".

2) With alignment tool, adjust either trimmer (C3 or C6 [Figure 4-2]) to bring "60" on calibration. (Seldom necessary to adjust both trimmers.)

- 3) Note output voltage. If not 9 volts:
 - (a) Correct for half of voltage error with trimmer adjusted in step 2.
 - (b) Adjust other trimmer to correct frequency error.

d. Repeat steps b and c until calibration is on and output is 9 volts at both "5" and "60".

e. Set RANGE switch at X100. Check tracking across range; if not within specifications, proceed as explained in paragraph 4-11.

- f. Check "5" and "60" points on X10K, X1K, and X1 ranges.
 - 1) Except for high end of X10K range, the X1, X10, X100, X1K, and X10K ranges should be within specifications.

2) If "60" on X10K range not on calibration, adjust C7 (Figure 4-3).

4-11 TRACKING ADJUSTMENTS**HIGH END OF RANGE**

- a. Set RANGE switch on X100.
- b. Slip dial to set "20" right on calibration.
- c. Turn frequency dial to "5", and adjust AMPLITUDE control to obtain output of 9 volts.
- d. Turn frequency dial to "60".
 - 1) If "60" not on calibration, adjust either trimmer (C3 or C6) until "60" is on calibration.
 - 2) Check output voltage. If not 9 volts:
 - (a) Correct for half of voltage error with one trimmer adjusted in step 1.
 - (b) Correct frequency error with other trimmer.

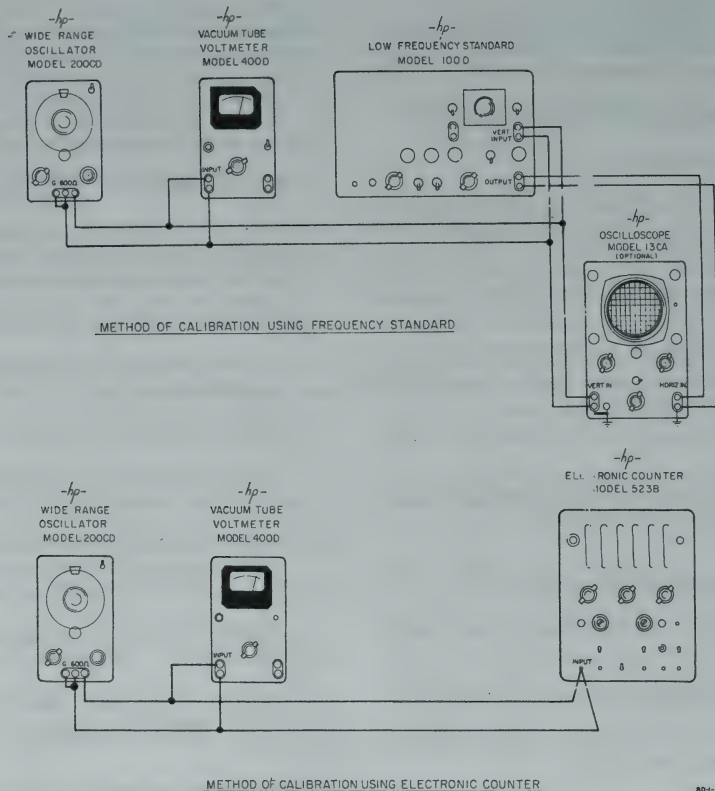


Figure 4-1. Model 200CD Calibration Procedure Equipment Arrangement

- e. Repeat steps c and d until calibration is on at "60" and output is 9 volts at both "5" and "60".

High end of dial will now track within specifications.

LOW END OF RANGE

- a. Check rest of dial, and find which cardinal points are off calibration. Leave RANGE switch at X100.
- b. For each point outside of specifications, bend associated tuning-capacitor plates to bring point within specifications.

The bending operation must always start with highest-frequency point involved. For example, if calibration is off at "7", "6", and "5", start bending at plates associated with "7".

To raise the frequency of oscillation, spread plates.
To lower the frequency, squeeze plates.

4-12 POWER TRANSFORMER PRIMARY CONNECTIONS

Connections to the primary winding of power transformer T3 are brought out to a terminal strip (identified in Figure 4-3) mounted on the right side of the instrument.

The power transformer primaries of the Model 200CD are connected for 115-volt operation at the factory. If the instrument is to be operated from a 230-volt power source:

- a. Reconnect the T3 primaries for 230-volt operation, as indicated on the schematic diagram.
- b. Replace a 1-ampere fuse F1 with a 1/2 ampere fuse of the type specified in the Table of Replaceable Parts.

4-13 TROUBLE SHOOTING CHART

The following chart lists various symptoms of trouble and for each indicates the part or parts of the circuit which should be checked. In the main, for purposes of simplification, only the tubes are referenced, but it should be remembered that components as-

sociated with referenced tubes also are failure possibilities. Within each section of the chart, checking should be performed in the order given since it is assumed throughout a procedure that the parts checked previously are functioning correctly.

When testing the Model 200CD, it is recommended that line voltage be applied to the instrument through a variable transformer, and that the transformer be adjusted to deliver a voltage at the low end of the rated 105- to 125-volt range. An instrument in good condition operates satisfactorily from any line voltage within rated range, but where there is marginal operation (from weak tubes, etc.) weaknesses become easier to trace at low line voltages.

TROUBLE SHOOTING CHART

SYMPTOM AND POSSIBLE CAUSE	TEST PROCEDURE	REMEDY
1. Instrument NOT operating index window NOT lighted.		
a. Fuse open due to defective fuse or overload in power supply.	a. Replace fuse. If new fuse blows, remove V5 and replace fuse. (1) Blowing of 2nd fuse indicates: A. Short circuit in wiring associated with T3. B. Short circuit in filament wiring. C. Defective transformer T3. (2) No opening of 2nd fuse with V5 removed indicates: A. Defective rectifier V5. B. Internal short circuit in V1, V2, V3, or V4. C. Short circuit in d-c wiring. D. Defective C13ABC. D-c resistance from pin 8 of V5 to ground normally is approximately 5 megohms; disconnect line voltage before measuring.	A. Locate and clear short. B. Locate and clear short. C. Replace transformer. A. Replace V5. B. Locate and replace defective tube. C. Locate and clear short. D. If defective, replace C13.
b. Poor connection to line voltage.	b. Check power cable, and connections at both ends of cable.	
2. Instrument NOT operating; index window lighted.		
a. Power supply not operating properly.	a. Check level of d-c voltage at power supply output; should be $325V \pm 10\%$. Use d-c voltmeter such as Model 410B; connect voltmeter + terminal to terminal 3 or 4 on capacitor C13, and voltmeter-terminal to C13 terminal 1. If voltmeter indication not $325V \pm 10\%$, check rectifier tube V5, and then other components of power supply.	a. Replace defective component.
b. Defective tube in oscillator circuit.	b. Check for bad V1, V2, V3, or V4 by substituting tube of same type known to be good.	b. Replace defective tube. See paragraph 4-3.

TROUBLE SHOOTING CHART (Continued)

SYMPTOM AND POSSIBLE CAUSE	TEST PROCEDURE	REMEDY
<p>c. Short circuit in tuning capacitor C5, variable capacitor C3 or C6 or fixed capacitor C4.</p> <p>d. Capacitor C5 shorted to ground.</p> <p>e. Defective lamp (R13 or R14).</p>	<p>c. (1) To check capacitors C5A, C5B, C3, and C4: A. Disconnect Model 200CD from line. B. Connect one ohmmeter terminal to C5 terminal designated C5B on Figure 4-2, and other to chassis. C. Turn RANGE switch to X1. D. Ohmmeter should indicate approximately 25.79M.</p> <p>(2) To check capacitors C5C, C6: A. Connect one ohmmeter terminal to C5 common terminal (Figure 4-2) and other to chassis. B. With 200CD disconnected from line and RANGE switch on X1, ohmmeter should indicate approximately 50.18M.</p> <p>d. (1) Connect one ohmmeter terminal to C5 terminal (designated C5C on Figure 4-2), and other to chassis.</p> <p>(2) With 200CD disconnected from line and RANGE switch at any setting, ohmmeter should indicate approximately 10K.</p> <p>e. See paragraph 4-4.</p>	<p>c. If resistance measurements indicate short, before making further checks, visually examine C5. If C5 is dirty, gently blow dust from plates with air hose, and then again make resistance measurements.</p> <p>d. If resistance measurement indicates short, check for defect in insulation between C5 and instrument chassis.</p>
<p>3. Instrument operating properly on only part of the range.</p> <p>a. Dirty contacts on RANGE.</p> <p>b. Open RANGE switch resistor.</p>	<p>a. Examine all sections of RANGE switch for dirty contacts.</p> <p>b. Check resistors associated with affected range.</p>	<p>a. Contacts may be cleaned with E-Z Aid or other silver dip.</p> <p>b. Replace resistor or RANGE switch. See paragraphs 4-9 and 4-10.</p>
<p>4. Instrument operating properly on X1K, X10K; not operating properly on X1, X10, X100.</p> <p>a. Dirty contacts on RANGE switch.</p> <p>b. Defect in transformer T2.</p>	<p>a. Examine RANGE switch contacts for dirt, particularly in sections S1C, D, E, F, G, H. Sections S1C, D, E, F are on wafer ahead of transformer shield, sections S1G, H are on wafer behind shield.</p> <p>b. Check T2.</p>	<p>a. Contact may be cleaned with E-Z Aid or other silver dip.</p> <p>b. Replace T2 if defective.</p>

TROUBLE SHOOTING CHART (Continued)

SYMPTOM AND POSSIBLE CAUSE	TEST PROCEDURE	REMEDY
<p>5. Instrument operating properly on X1, X10, X100; not operating properly on X1K, X10K.</p> <p>a. Dirty contacts on RANGE switch.</p> <p>b. Defect in transformer T1.</p>	<p>a. Examine RANGE switch contacts for dirt, particularly in sections SIC, D, E, F, G, H.</p> <p>b. Check T1.</p>	<p>a. Contacts may be cleaned with E-Z-Aid or other silver dip.</p> <p>b. Replace T1 if defective.</p>
<p>6. Distortion in output.</p> <p>a. Bad tube in oscillator circuit.</p> <p>b. Incorrect potentials on tube pins.</p> <p>c. Dust on plates of tuning capacitor C5.</p> <p>d. Defective lamp (R13 or R14).</p>	<p>a. See paragraphs 4-3 and 4-8.</p> <p>b. (1) Check as described in 2a, above.</p> <p>(2) Check d-c voltage on pins of all tube sockets; except as noted in Figure 4-6, voltages should be within $\pm 10\%$ of values shown in schematic or Figure 4-6.</p> <p>c. Inspect visually.</p> <p>d. See paragraph 4-4.</p>	<p>(1) Replace defective tube. See paragraph 4-3.</p> <p>(2) If potential on any pin not correct value, check resistors in power-supply network associated with incorrect potential.</p> <p>c. With air hose, gently blow out dust.</p>
<p>7. Noise present in output waveform when AMPLITUDE control is rotated; output voltage unstable when AMPLITUDE control is rotated.</p> <p>a. Defective AMPLITUDE control (R39).</p>		<p>a. Replace R39 (see paragraph 4-6).</p>

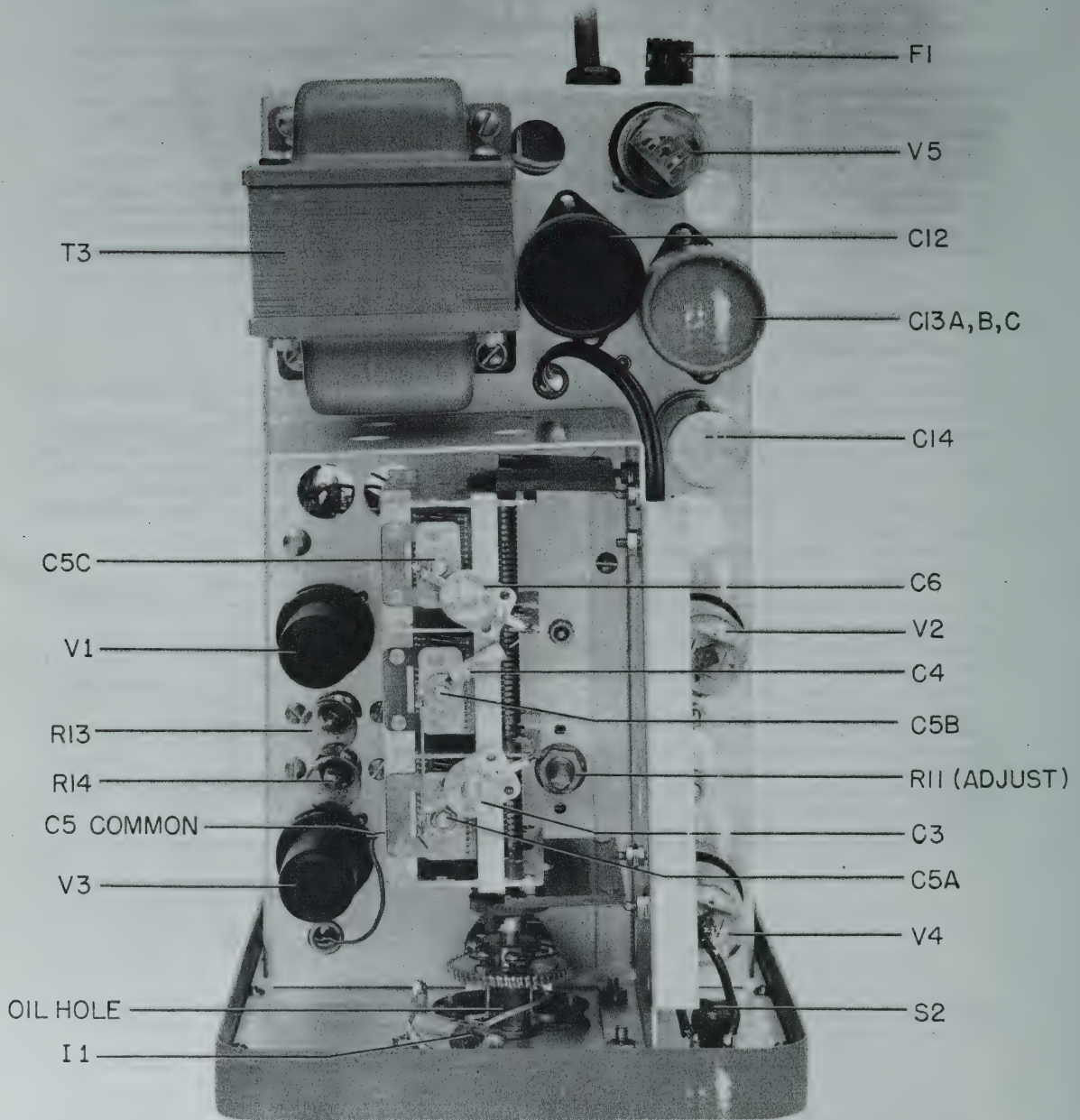


Figure 4-2 Model 200CD Top View Cover Removed

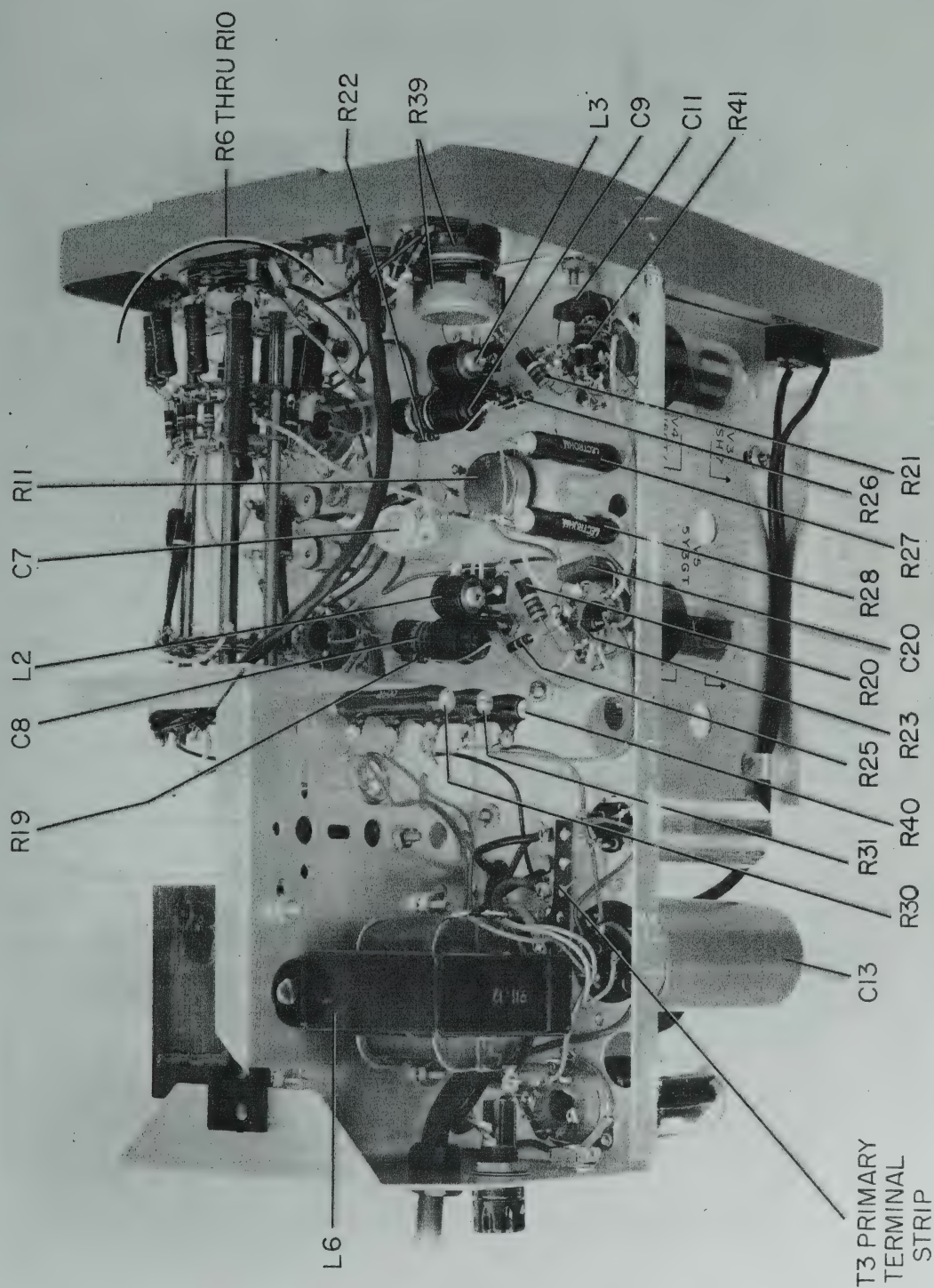


Figure 4-3 Model 200CD View of Right Side Bottom Side Up

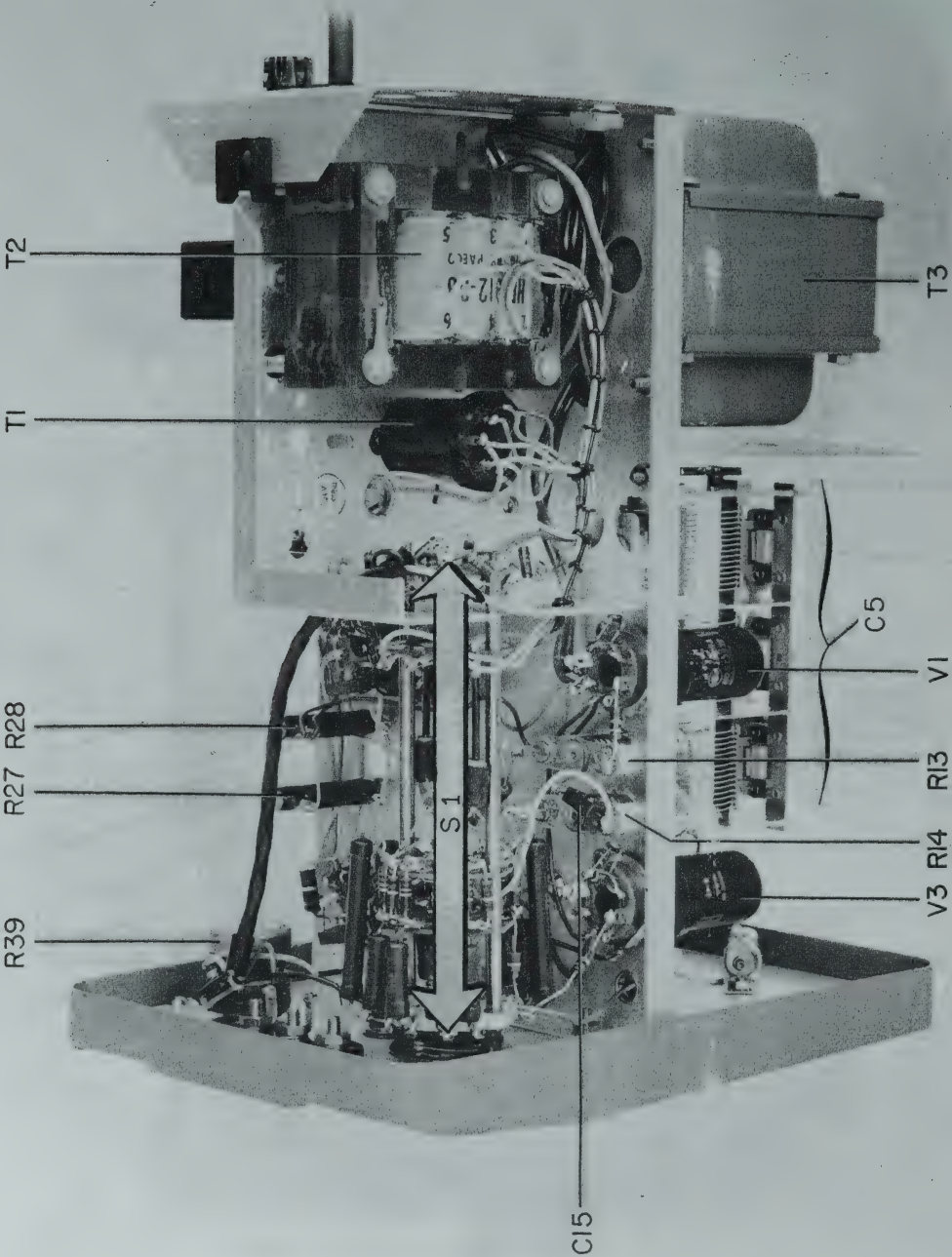


Figure 4-4 Model 200CD View of Left Side Bottom Side Up

NOTES:

- CONDITIONS OF DC VOLTAGE MEASUREMENT
 1. BETWEEN INDICATED POINT AND CHASSIS WITH
 VOLTMETER OF 122 MEGOHMS INPUT RESISTANCE
 2. LINE VOLTAGE 115/230 VOLTS, 50-1000 \sim
 3. AMPLITUDE CONTROL AT ZERO
 4. RANGE SWITCH AT X100
 5. FREQUENCY DIAL AT "10"

CONDITIONS OF RESISTANCE MEASUREMENT
 1. BETWEEN INDICATED POINT AND CHASSIS WITH
 OHMMETER

2. DISCONNECTED FROM LINE VOLTAGE
 3. CAPACITORS CHARGED BY OHMMETER BEFORE
 READINGS TAKEN
 DNA = RESISTANCE MEASUREMENT IMPRACTICAL DUE
 TO HIGH CAPACITANCE IN PARALLEL WITH HIGH
 RESISTANCE TO GROUND, VALUE IN PARENTHESES
 APPROXIMATE

CONDITIONS OF AC VOLTAGE MEASUREMENT
 1. BETWEEN INDICATED POINT AND NEGATIVE BUS

- * = VOLTAGE MAY VARY UP TO $\pm 20\%$
 ** = TIE POINT

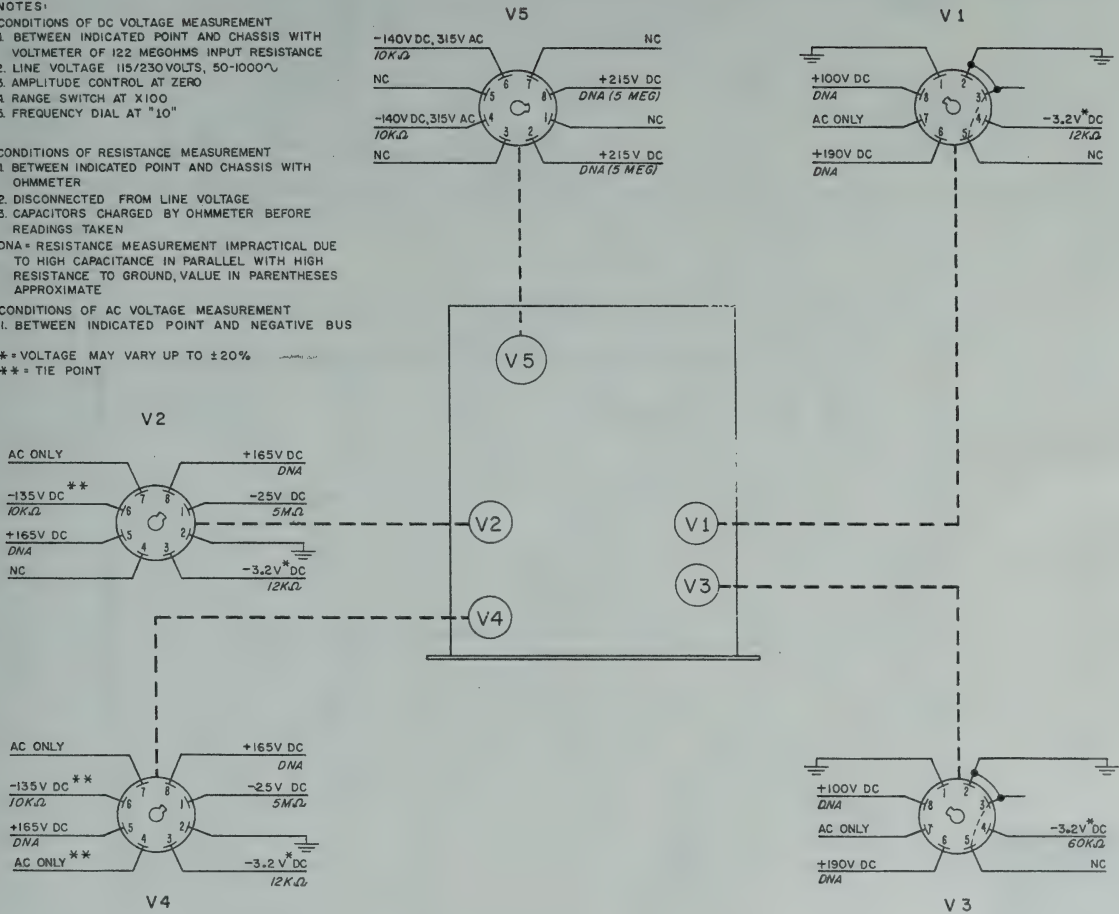


Figure 4-5. Model 200CD Tube Socket Voltage-Resistance Diagram

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maintenance of Hewlett-Packard equipment and is
not to be used otherwise or reproduced without written
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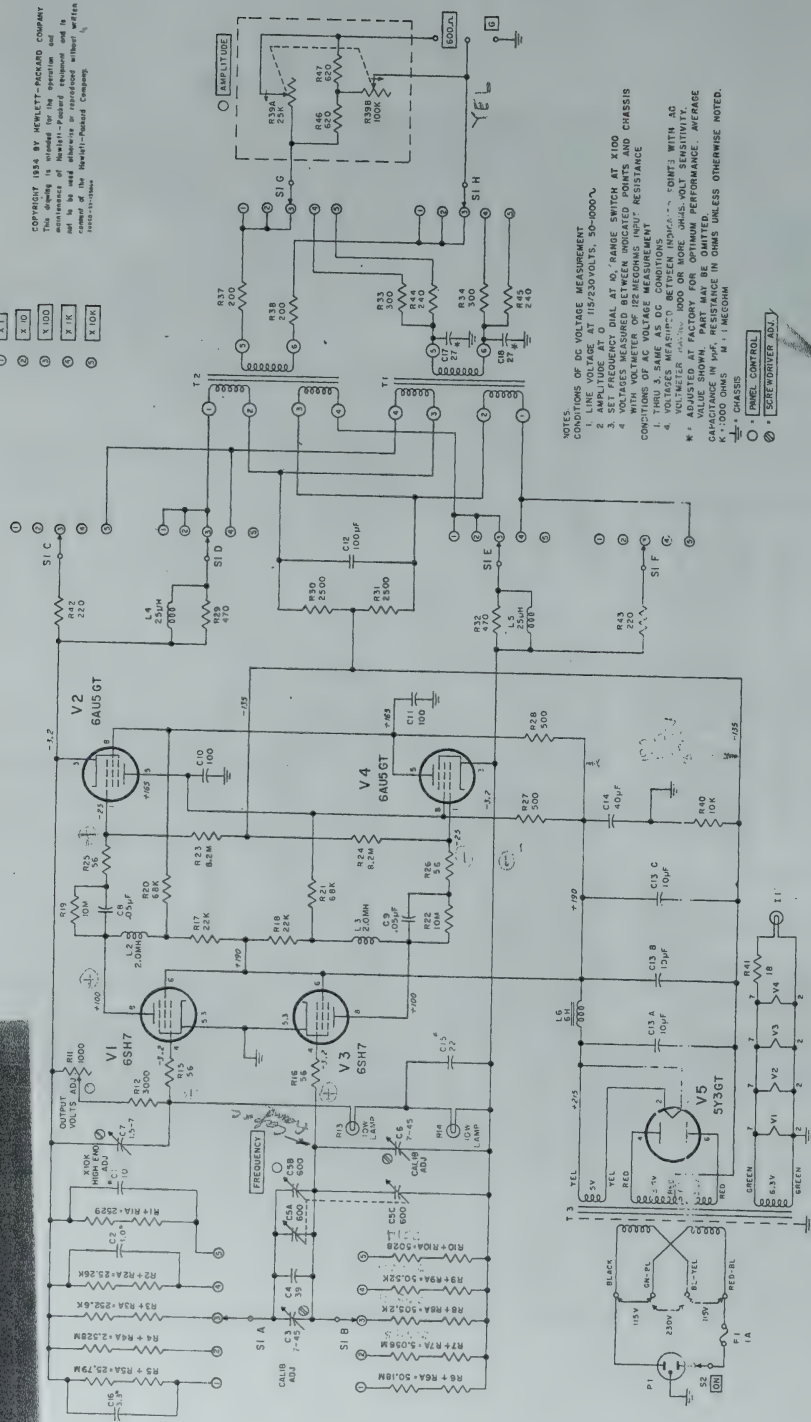


Figure 4-6. Model 200CD Wide Range Oscillator

SECTION V

TABLE OF REPLACEABLE PARTS

NOTE

Any changes in the Table of Replaceable Parts will be listed on a Production Change sheet at the front of this manual.

When ordering parts from the factory always include the following information:

Instrument Model Number

Serial Number

④ Stock Number of Part

Description of Part

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	ϕ STOCK NO.	#			
C1	Capacitor: fixed, ceramic, 10 μ f, ± 5 μ f, 500 vdcw Electrical value adjusted at factory K*	15-30	1			
C2	Capacitor: fixed, titanium dioxide, 1 μ f, $\pm 10\%$, 500 vdcw Electrical value adjusted at factory DD*	15-102	1			
C3	Capacitor: variable, ceramic 7-45 μ f, 500 vdcw L*	13-1	1			
C4	Capacitor: fixed, ceramic, 39 μ f, $\pm 5\%$, 500 vdcw K*	15-4	1			
C5	Capacitor: variable, 3 sections, 600 μ f/sect. W*	12-28	1			
C6	Same as C3					
C7	Capacitor: variable, ceramic, 1.5-7 μ f, 500 vdcw L*	13-7	1			
C8, 9	Capacitor: fixed, paper, .047 μ f, $\pm 10\%$, 600 vdcw CC*	16-15	2			
C10, 11	Capacitor: fixed, mica, 100 μ f, $\pm 10\%$, 500 vdcw V*	14-100	2			
C12	Capacitor: fixed, electrolytic, 100 μ f, 100 vdcw CC*	18-25HP	1			
C13 A, B, C	Capacitor: fixed, electrolytic, 3 sections, 10 μ f/sect., 450 vdcw CC*	18-31HP	1			
C14	Capacitor: fixed, electrolytic, 40 μ f, 450 vdcw CC*	18-40HP	1			
C15	Capacitor: fixed, mica, 22 μ f, $\pm 10\%$, 300 vdcw Electrical value adjusted at factory V*	14-69	1			
C16	Capacitor: fixed, titanium dioxide, 3.3 μ f, $\pm 10\%$, 500 vdcw Electrical value adjusted at factory DD*	15-78	1			
C17, 18	Capacitor: fixed, mica, 27 μ f, $\pm 10\%$, 500 vdcw Electrical value adjusted at factory V*	14-17	2			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	#			
F1	Fuse, cartridge: 1 amp, 115V operation E*	211-18	1			
	or					
	Fuse, cartridge: 1/2 amp, 230V operation E*	211-20				
I1	Lamp, incandescent: 6-8V, .15 amp, #47 N*	211-47	1			
L1	This circuit reference not assigned					
L2, 3	Reactor, R. F., coil, 2.0 MH HP*	200CD- 69C	2			
L4, 5	Coil, R. F., filter, 25 μ h HP*	200CD- 60B	2			
L6	Reactor: filter, choke, 240 ohms Paeco	911-12	1			
P1	Power Cord Elec. Cords Co.	812-56	1			
R1	Resistor: fixed, deposited carbon, 2450 ohms, $\pm 1\%$, 1 W NN*	31-2450	1			
R2	Resistor: fixed, deposited carbon, 24,500 ohms, $\pm 1\%$, 1 W NN*	31-24.5K	1			
R3	Resistor: fixed, deposited carbon, 245,000 ohms, $\pm 1\%$, 1 W NN*	31-245K	1			
R4	Resistor: fixed, deposited carbon, 2.45 megohms, $\pm 1\%$, 1 W NN*	31-2.45M	1			
R5	Resistor: fixed, deposited carbon, 24.5 megohms, $\pm 1\%$, 2 W NN*	32-24.5M	1			
R6	Resistor: fixed, deposited carbon, 49 megohms, $\pm 1\%$, 2 W NN*	32-49M	1			
R7	Resistor: fixed, deposited carbon, 4.9 megohms, $\pm 1\%$, 1 W NN*	31-4.9M	1			
R8	Resistor: fixed, deposited carbon, 490,000 ohms, $\pm 1\%$, 1 W NN*	31-490K	1			
R9	Resistor: fixed, deposited carbon, 49,000 ohms, $\pm 1\%$, 1W NN*	31-49K	1			
R10	Resistor: fixed, deposited carbon, 4900 ohms, $\pm 1\%$, 1 W NN*	31-4900	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#			
R11	Resistor: variable, composition, 1000 ohms, $\pm 20\%$, 1/2 W G*	210-51	1			
R12	Resistor: fixed, composition, 3000 ohms, $\pm 5\%$, 1 W B*	24- 300C-5	1			
R13, 14	Lamp, incandescent: 250V, 10W N*	211-29	2			
R15, 16	Resistor: fixed, composition, 56 ohms, $\pm 10\%$, 1/2 W B*	23-56	2			
R17, 18	Resistor: fixed, composition, 22,000 ohms, $\pm 10\%$, 1 W B*	24-22K	2			
R19	Resistor: fixed, composition, 10 megohms, $\pm 5\%$, 1/2 W B*	23- 10M-5	1			
R20, 21	Resistor: fixed, composition, 68,000 ohms, $\pm 10\%$, 1 W B*	24-68K	2			
R22	Same as R19					
R23, 24	Resistor: fixed, composition, matched pair, 8.2 megohms, 1/2 W HP*	200CD- 67	1			
R25, 26	Same as R15					
R27, 28	Resistor: fixed, wirewound, 500 ohms, $\pm 10\%$, 10 W S*	26-5	2			
R29	Resistor: 470 ohms, part of L4					
R30, 31	Resistor: fixed, matched pair, 2500 ohms HP*	200J- 26	1			
R32	Resistor: 470 ohms, part of L5					
R33, 34	Resistor: fixed, composition, 300 ohms, $\pm 5\%$, 1/2 W B*	23- 300-5	2			
R35, 36	These circuit references not assigned					
R37, 38	Resistor: fixed, composition, 200 ohms, $\pm 5\%$, 1/2 W B*	23-200- 5	2			
R39 A, B	Output Attenuator Assembly: 600 ohm delta "T", includes R46 and 47. HP*	200CD- 34	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	④ STOCK NO.	#			
R40	Resistor: fixed, wirewound, 10,000 ohms, $\pm 10\%$, 10 W S*	26-10	1			
R41	Resistor: fixed, composition, 18 ohms, $\pm 10\%$, 1 W B*	24-18	1			
R42, 43	Resistor: fixed, composition, 220 ohms, $\pm 10\%$, 1 W B*	24-220	2			
R44, 45	Resistor: fixed, composition, 240 ohms, $\pm 5\%$, 1/2 W B*	24-240-5	2			
R46, 47	Resistor: fixed, composition, 620 ohms, $\pm 5\%$, 1/2 W part of Output Attenuator Assembly B*	23-620-5	2			
S1	Range Switch Assembly HP*	200CD- 19WB	1			
S2	Switch, toggle: SPST D*	310-11	1			
T1	Transformer, output: high frequency HP*	200CD- 9	1			
T2	Transformer, output: low frequency Paeco	912-38	1			
T3	Transformer, power Paeco	910-94	1			
V1	Tube, electron: 6SH7 ZZ*	G-73AB	2			
	Tubes selected for best performance will supplied by ④ (if ordered by ④ Stock No.) but tubes meeting RETMA standards will normally result in the instrument operating within specifications.					
V2	Tube, electron: 6AU5GT ZZ*	212- 6AU5GT	2			
V3	Same as V1					
V4	Same as V2					
V5	Tube, electron: 5Y3GT ZZ*	212- 5Y3GT	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#			
	MISCELLANEOUS					
	Binding Post Assembly: ground with link HP*	G-76J	1			
	Binding Post Assembly: red HP*	AC-10D	2			
	Coupler, insulated HP*	AC-32A	1			
	Disc, vernier drive on shaft HP*	G-14A	1			
	Disc, vernier drive HP*	G-14B	1			
	Fuseholder T*	140-16	1			
	Insulator, binding post: black HP*	AC-54B	1			
	Knob: AMPLITUDE HP*	G-74K	1			
	Knob: RANGE HP*	G-74N	1			
	Knob: frequency dial vernier HP*	G-74F	1			
	Knob: frequency dial HP*	G-74Z	1			
	Spring, compression, for vernier drive Connor Spring Co.	146-23	1			
	Window, dial for curved frequency dial HP*	G-99K	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

Total quantity used in the instrument.

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS	CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.	AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
B	Allen-Bradley Co.	Milwaukee 4, Wis.	AL	Industrial Condenser Corp.	Chicago 18, Ill.
C	Amperite Co.	New York, N. Y.	AM	Insuline Corp. of America	Manchester, N. H.
D	Arrow, Hart & Hegeman	Hartford, Conn.	AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
E	Bussman Manufacturing Co.	St. Louis, Mo.	AO	E. F. Johnson Co.	Waseca, Minn.
F	Carborundum Co.	Niagara Falls, N. Y.	AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
G	Centralab	Milwaukee 1, Wis.	AQ	Micro-Switch	Freeport, Ill.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.	AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
HP	Hewlett-Packard Co.	Palo Alto, Calif.	AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
I	Clarostat Mfg. Co.	Dover, N. H.	AT	The Muter Co.	Chicago 5, Ill.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.	AU	Ohmite Mfg. Co.	Skokie, Ill.
K	Hi-Q Division of Aerovox	Olean, N. Y.	AV	Resistance Products Co.	Harrisburg, Pa.
L	Erie Resistor Corp.	Erie 6, Pa.	AW	Radio Condenser Co.	Camden 3, N. J.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.	AX	Shallcross Manufacturing Co.	Collingdale, Pa.
N	General Electric Co.	Schenectady 5, N. Y.	AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
O	General Electric Supply Corp.	San Francisco, Calif.	AZ	Sealectro Corp.	New Rochelle, N. Y.
P	Girard-Hopkins	Oakland, Calif.	BA	Spencer Thermostat	Attleboro, Mass.
Q	Industrial Products Co.	Danbury, Conn.	BC	Stevens Manufacturing Co.	Mansfield, Ohio
R	International Resistance Co.	Philadelphia 8, Pa.	BD	Torrington Manufacturing Co.	Van Nuys, Calif.
S	Lectrohm Inc.	Chicago 20, Ill.	BE	Vector Electronic Co.	Los Angeles 65, Calif.
T	Littlefuse Inc.	Des Plaines, Ill.	BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
U	Maguire Industries Inc.	Greenwich, Conn.	BG	Advance Electric & Relay Co.	Burbank, Calif.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.	BH	E. I. DuPont	San Francisco, Calif.
W	Oak Manufacturing Co.	Chicago 10, Ill.	BI	Electronics Tube Corp.	Philadelphia 18, Pa.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.	BJ	Aircraft Radio Corp.	Boonton, N. J.
Y	Radio Corp. of America	Harrison, N. J.	BK	Allied Control Co., Inc.	New York 21, N. Y.
Z	Sangamo Electric Co.	Marion, Ill.	BL	Augat Brothers, Inc.	Attleboro, Mass.
AA	Sarkes Tarzian	Bloomington, Ind.	BM	Carter Radio Division	Chicago, Ill.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.	BN	CBS Hytron Radio & Electric	Denvers, Mass.
CC	Sprague Electric Co.	North Adams, Mass.	BO	Chicago Telephone Supply	Elkhart, Ind.
DD	Stackpole Carbon Co.	St. Marys, Pa.	BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
EE	Sylvania Electric Products Co.	Warren, Pa.	BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
FF	Western Electric Co.	New York 5, N. Y.	BR	Allen B. DuPont Labs	Clifton, N. J.
GG	Wilkor Products, Inc.	Cleveland, Ohio	BS	Excel Transformer Co.	Oakland, Calif.
HH	Amphenol	Chicago 50, Ill.	BT	General Radio Co.	Cambridge 39, Mass.
II	Dial Light Co. of America	Brooklyn 37, N. Y.	BU	Hughes Aircraft Co.	Culver City, Calif.
JJ	Leecraft Manufacturing Co.	New York, N. Y.	BV	International Rectifier Corp.	El Segundo, Calif.
KK	Switchcraft, Inc.	Chicago 22, Ill.	BW	James Knights Co.	Sandwich, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.	BX	Mueller Electric Co.	Cleveland, Ohio
MM	Carad Corp.	Redwood City, Calif.	BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
NN	Electra Manufacturing Co.	Kansas City, Mo.	BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
OO	Acro Manufacturing Co.	Columbus 16, Ohio	CA	Raytheon Manufacturing Co.	Newton, Mass.
PP	Alliance Manufacturing Co.	Alliance, Ohio	CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
QQ	Arco Electronics, Inc.	New York 13, N. Y.	CD	Varian Associates	Palo Alto, Calif.
RR	Astron Corp.	East Newark, N. J.	CE	Victory Engineering Corp.	Union, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.	CF	Weckesser Co.	Chicago 30, Ill.
TT	Belden Manufacturing Co.	Chicago 44, Ill.	CG	Wilco Corporation	Indianapolis, Ind.
UU	Bird Electronics Corp.	Cleveland 14, Ohio	CH	Winchester Electronics, Inc.	Santa Monica, Calif.
VV	Barber Colman Co.	Rockford, Ill.	CI	Malco Tool & Die	Los Angeles 42, Calif.
WW	Bud Radio Inc.	Cleveland 3, Ohio	CJ	Oxford Electric Corp.	Chicago 15, Ill.
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.	CK	Camloc-Fastener Corp.	Paramus, N. J.
YY	Cinema Engineering Co.	Burbank, Calif.	CL	George K. Garrett	Philadelphia 34, Pa.
ZZ	Any brand tube meeting REMA standards.		CM	Union Switch & Signal	Swissvale, Pa.
AB	Corning Glass Works	Corning, N. Y.	CN	Radio Receptor	New York 11, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.	CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
AD	The Drake Mfg. Co.	Chicago 22, Ill.	CP	Bassick Co.	Bridgeport 2, Conn.
AE	Elco Corp.	Philadelphia 24, Pa.	CQ	Birnback Radio Co.	New York 13, N. Y.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.	CR	Fischer Specialties	Cincinnati 6, Ohio
AG	Thomas A. Edison, Inc.	West Orange, N. J.	CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.	CT	Potter-Brumfield Co.	Princeton, Ind.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.	CU	Cannon Electric Co.	Los Angeles, Calif.
AJ	The Gudeman Co.	Sunnyvale, Calif.	CV	Dynac, Inc.	Palo Alto, Calif.
			CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

HEWLETT PACKARD
C

200CD

WIDE RANGE OSCILLATOR

OPERATING AND SERVICING MANUAL



CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.
2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY

Laboratory Instruments for Speed and Accuracy

275 PAGE MILL ROAD

CABLE



PALO ALTO, CALIF. U.S.A.

"HEWPACK"

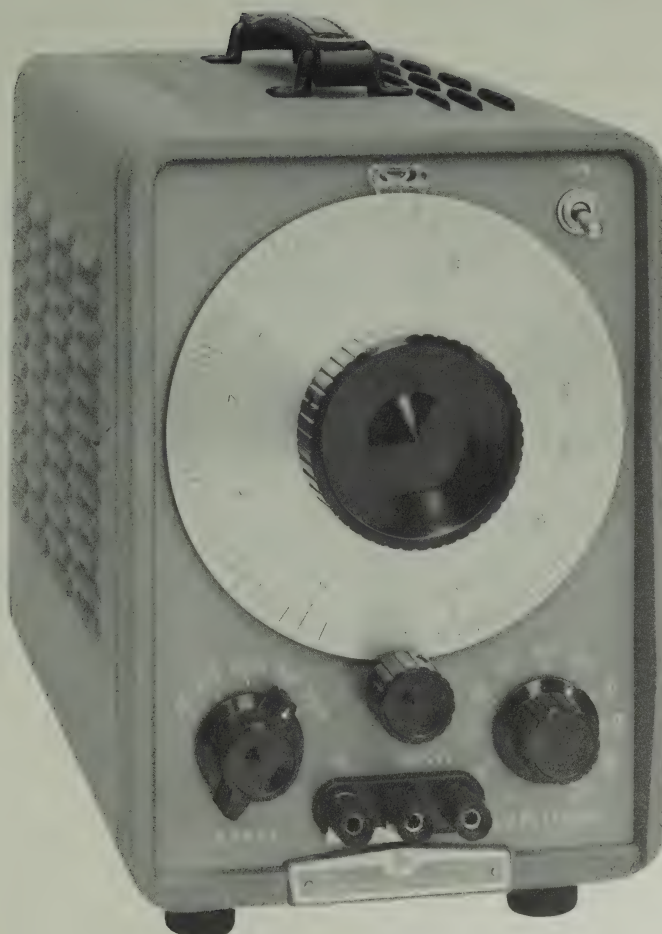
OPERATING AND SERVICING MANUAL

FOR

MODEL 200CD/CDR

WIDE RANGE OSCILLATOR

SERIAL 8739 AND ABOVE



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275 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

200C001-4

SPECIFICATIONS

FREQUENCY RANGE: 5 cps to 600 kc covered in five ranges.

RANGES:	X1	5 cps to	60 cps
	X10	50 cps to	600 cps
	X100	500 cps to	6 kc
	X1,000	5 kc to	60 kc
	X10,000	50 kc to	600 kc

ACCURACY: $\pm 2\%$ including calibration error, warm-up, changes due to aging of components, tubes, etc.

DIAL: Six inch diameter calibrated over 300° of arc. 85 divisions. Total scale length, 78 inches.

FREQUENCY RESPONSE: ± 1 db entire frequency range (reference 1 kc).

OUTPUT: 160 milliwatts (10 volts) into 600 ohm rated load, 20 volts open circuit.

OUTPUT BALANCE: Better than .1% at lower frequencies and approximately 1% at higher frequencies.

INTERNAL IMPEDANCE: 600 ohms. Output is balanced to ground for zero position of output attenuator. (May be operated with one side grounded if desired.)

DISTORTION: Less than 0.5% below 500 KC; less than 1% 500 KC and above. Independent of load impedance.

HUM VOLTAGE: Less than 0.1% of rated output.
Decreases as output is attenuated.

POWER: 115/230 volts, $\pm 10\%$, 50/1000 cps, 75 watts.

ACCESSORIES AVAILABLE: Φ AC-60A Line Matching Transformer, 5 to 600 kc (provides balanced output at any attenuator setting at 135 and 600-ohms).

Φ AC-16A Cable Assembly, 44" RG-58/U Cable terminated each end with dual banana jack plugs.

DIMENSIONS: Cabinet Mount: 7-1/2" wide, 11-1/2" high, 14-1/4" deep.
Rack Mount: 19" wide, 7" high, 14-1/4" deep,
depth behind panel 13".

WEIGHT: Cabinet Mount: 23 lbs., shipping weight approximately 29 lbs.
Rack Mount: 27 lbs., shipping weight approximately 35 lbs.

CONTENTS

SECTION I GENERAL DESCRIPTION

1 - 1	General Description	I - 1
1 - 2	Power Cable	I - 1
1 - 3	230 Volt Operation	I - 1
1 - 4	Inspection	I - 1

SECTION II OPERATING INSTRUCTIONS

2 - 1	Operating Procedure	II - 1
2 - 2	Output Circuit Options	II - 1

SECTION III CIRCUIT DESCRIPTION

3 - 1	General	III - 1
3 - 2	Frequency-Controlling Bridge	III - 1
3 - 3	Amplifier	III - 2
3 - 4	Output Circuit	III - 2

SECTION IV MAINTENANCE

4 - 1	General	IV - 1
4 - 2	Cover Removal	IV - 1
4 - 3	Tube Replacement	IV - 1
4 - 4	Replacement of Lamps R13 and R14	IV - 1
4 - 5	Replacement of Electrolytic Capacitors	IV - 2
4 - 6	Replacement of Variable Resistors and Capacitors	IV - 2
4 - 7	Lubrication, Tuning-Capacitor Drive Mechanism	IV - 2
4 - 8	Check for Cause of Distortion	IV - 2
4 - 9	Replacement of Range Switch	IV - 2
4 - 10	Calibration	IV - 2
4 - 11	Tracking Adjustments	IV - 3
4 - 12	Power Transformer Primary Connections	IV - 4
4 - 13	Trouble Shooting Chart	IV - 5

SECTION V TABLE OF REPLACEABLE PARTS

5 - 1	Table of Replaceable Parts	V - 1
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SECTION I

GENERAL DESCRIPTION

1-1 GENERAL DESCRIPTION

The Model 200CD Wide Range Oscillator generates frequencies of excellent waveform in the subsonic, audio, and supersonic ranges (5 cycles to 600 kc, in five overlapping decade bands). The Model 200CD includes new design features which result in still finer performance than previous Φ instruments. Special circuitry ensures an output voltage of low distortion and high stability with any output load impedance from zero ohms to open circuit. Usefulness of the oscillator has been extended by designing the 200CD output circuit so that the instrument may be operated balanced as well as unbalanced and by providing a 600-ohm impedance match.

The Model 200CD is easy to operate: frequency and amplitude of the output voltage are set merely by operating dials on the control panel. The easily-read, six-inch diameter frequency dial is calibrated over 300° of arc, and has an effective scale length of approximately 80 inches.

The Model 200CD furnishes up to 10 volts into a 600-ohm load (20 volts open circuit) at any frequency from 5 cps to 600 kc. A bridged tee variable attenuator in the output circuit controls the output power.

The Model 200CD provides an ideal signal source for testing servo and vibrating systems, medical and geophysical equipment, audio amplifier circuits and transducers, sonar and supersonic apparatus, carrier telephone systems, video frequency circuits, and low radio-frequency equipment.

1-2 POWER CABLE

The three-conductor power cable supplied with this instrument is terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin added to a standard two blade connector which grounds the instrument chassis when used with an appropriate receptacle. To use this connector in a two-contact receptacle, a three-prong to two-prong adapter should be used. When the adapter is used the third contact is terminated in a short lead from the adapter which can then be connected to the outlet mounting box in order to ground the instrument chassis.

1-3 230-VOLT OPERATION

This instrument is normally wired for operation from a nominal 115 volt supply. Operation from a 230 volt source is easily accomplished by reconnecting the dual primary windings on the power transformer in series. Refer to the schematic drawing for the proper connections. Replace the 1 ampere slow blow fuse with a 1/2 ampere slow blow fuse.

1-4 INSPECTION

This instrument was thoroughly tested and inspected before being shipped, and is ready for use when received.

After the instrument is unpacked, it should be inspected carefully for damage received in transit. If any shipping damage is found, follow the procedure outlined in the "Claim for Damage in Shipment" page of this instruction book.

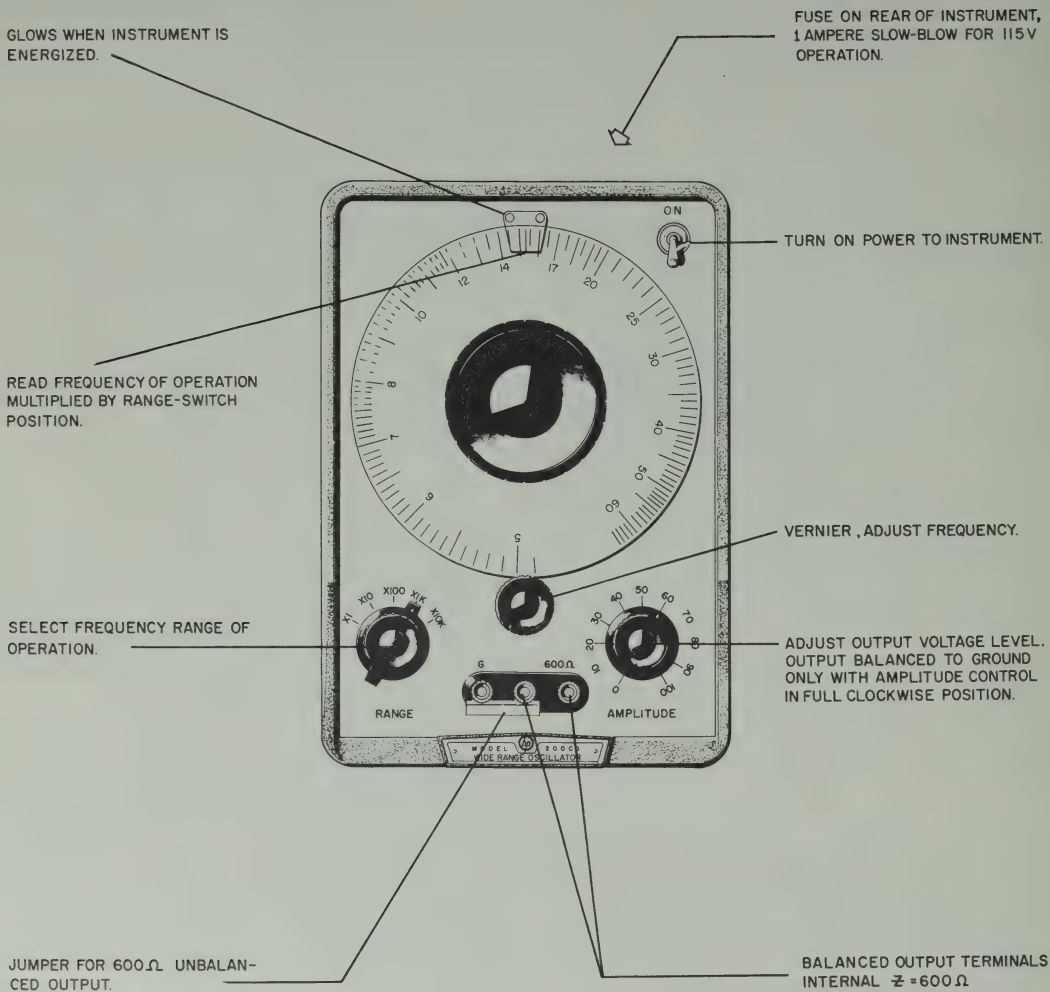


Figure 2-1 Controls and Terminals

SECTION II

OPERATING INSTRUCTIONS

2-1 OPERATING PROCEDURE

- a. With the instrument plugged into a power source of specified voltage and frequency, and the power switch at ON, allow a warm-up period of approximately five minutes. Where maximum accuracy is desired, this warm-up period should be extended at least to thirty minutes.

NOTE

If a 230-volt power source is used, check (1) that power transformer T3 is strapped for 230-volt operation (strapping options are shown on the schematic diagram), and (2) that fuse F1 is a 1/2 ampere Slo-Blo fuse. See paragraph 4-12.

- b. The frequency of the output voltage is determined (1) by the setting of the frequency dial and (2) by the setting of the RANGE switch. For example, to obtain a 1,000-cycle output, set the frequency dial at 10 and the RANGE switch at X100 (10 x 100 is 1,000).

- c. Turn the AMPLITUDE control to the zero position. Make the connection between the Model 200CD and the equipment to be driven at the terminals designated 600 Ω . (Connections are discussed in paragraph 2-2.)

The Model 200CD may be operated into a load of any value without effect on the output waveform. Loads of less than 600 ohms will decrease the maximum available output voltage, and loads of more than 600 ohms will increase the available output voltage. The Model 200CD may be considered as a 20-volt generator with a 600-ohm internal impedance.

- d. Adjust the AMPLITUDE control to obtain the desired level of output voltage.

2-2 OUTPUT CIRCUIT OPTIONS

The output circuit of the Model 200CD may be arranged for balanced or unbalanced operation. Typical connections for each are indicated in Figure 2-2.

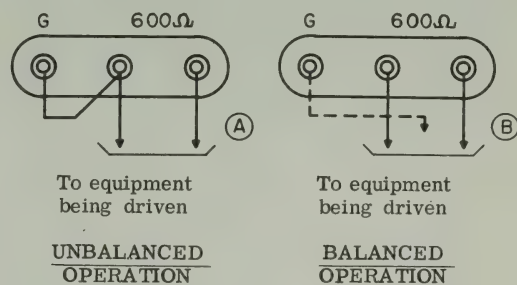


Figure 2-2. Model 200CD
Typical Output Connections

UNBALANCED OPERATION

To operate with one side grounded, a strap is placed between the G terminal and the center terminal, as indicated in Figure 2-2A.

BALANCED OPERATION

Connections for balanced operation are indicated in Figure 2-2B. (The broken line from the ground terminal indicates the output circuit is balanced to ground, within the tolerances given below.)

The AMPLITUDE control in the output circuit is a bridged tee attenuator and at any setting except minimum attenuation unbalances the circuit. Therefore, for balanced operation the AMPLITUDE control must be set for maximum output (full cw). Output balance

also is a function of frequency because of capacitive feed-through at higher frequencies. Up to 10 kc, however, unbalance is less than 0.1%, and at 600 kc is approximately 1%. If small outputs are desired, or if balance at higher frequencies is critical, turn the AMPLITUDE control maximum clockwise, and connect an external attenuator, designed for the frequencies involved, between the Model 200CD and the load.

A balanced output may also be obtained over the full range of the AMPLITUDE control by using an AC-60A/B Line Matching Transformer at the output terminals of the oscillator.

The following chart indicates the area where within 1% of balance may be obtained. This chart indicates balance obtainable at various settings of the AMPLITUDE control when operating into a 600-ohm load. Where other values of load are used, the chart does not apply directly but does apply for

settings of the AMPLITUDE control that would produce the indicated voltage across a 600-ohm load.

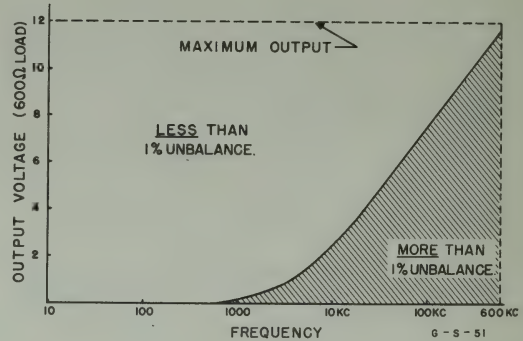


Figure 2-3. Model 200CD
Balance Chart Operating into 600-ohm Load

SECTION III

THEORY OF OPERATION

3-1 GENERAL

The Model 200CD Wide Range Oscillator uses a balanced (push-pull) oscillator circuit from which the output is taken directly, avoiding the complication and possible distortion of an isolating amplifier. Reaction of the load on the oscillator is avoided by the use of a zero source impedance output stage. This arrangement results in a simple, trouble-free circuit having low distortion and high stability over the entire frequency range.

Functionally, the circuits of the Model 200CD include a frequency-controlling bridge and balanced push-

pull amplifier which constitute the oscillator circuit, an output circuit which may be arranged either for balanced or unbalanced operation, and a power-supply circuit. These are shown in block diagram form in Figure 3-1 and in detail in the schematic diagram.

3-2 FREQUENCY-CONTROLLING BRIDGE

The frequency-controlling circuit is arranged as a floating bridge, symmetrical with respect to ground. With no connection to ground on any terminal of the bridge, stability of calibration is assured since any

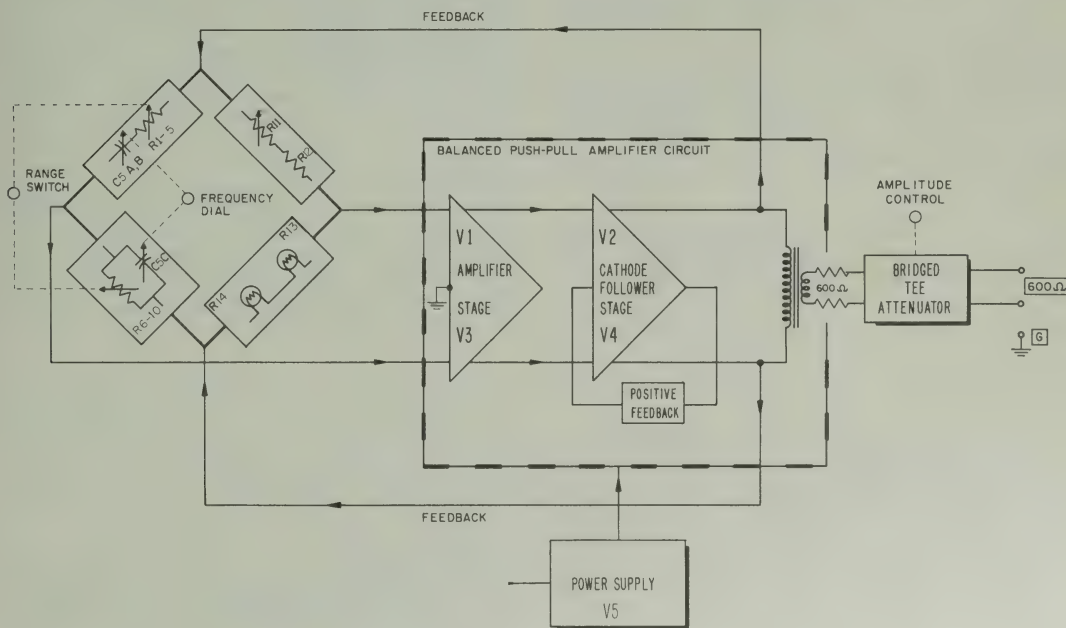


Figure 3-1. Model 200CD Block Diagram

stray capacity and leakage to ground present at the bridge output terminals do not shunt either the frequency-controlling or amplitude-stabilizing arms of the bridge. The frequency-controlling components (RC networks which are varied by operation of the RANGE switch and frequency dial) comprise two arms of the bridge, while the amplitude-stabilizing components (a voltage divider which includes a thermally-sensitive resistance) comprise the other two arms. The amplitude is stabilized at such a level that the amplifier tubes are operated in the substantially linear portion of their characteristics, which, together with the large negative feedback at harmonic frequencies, results in a very pure sine wave oscillation.

The bridge is fed by the balanced voltage developed at the cathodes of V2 and V4 in the output of the balanced amplifier. The output of the frequency-controlling branch of the bridge is applied to the grid of V3 and the output of the amplitude-stabilizing branch is applied to the grid of V1. The manner in which the voltage - versus - frequency and phase - versus - frequency characteristics of an RC network can be utilized with an amplifier of proper design to achieve an oscillator which delivers a voltage of excellent stability and waveform is well covered in texts such as Terman & Pettit's Electronic Measurements.

Variable resistor R11 is provided for adjustment of the amplitude-stabilizing branch of the bridge should it be found after replacement of lamp R13 or R14 that less or more than rated voltage is being delivered to the output terminals.

Variable capacitors C3, C6, and C7 are adjusted at the factory for optimum calibration and amplitude constancy with frequency. They should not require adjustment unless the RANGE switch is replaced.

3-3 AMPLIFIER

The oscillator amplifier is a balanced push-pull circuit which includes a voltage-amplifier stage (V1, V3) and a special cathode-follower stage (V2, V4). Criss-cross positive feedback is used in the cathode-follower stage to provide an essentially zero output impedance as seen by the cathode-to-cathode load. The feedback paths are from the plate of V2 to the control grid and screen of V4, and from the plate of V4 to the control grid and screen of V2. The degree of the positive feedback is a function of the load and increases as the load impedance decreases, thus tending to maintain the output constant regardless of load. Self-oscillation in the amplifier circuit

is prevented by proper choice of resistance in the feedback circuits and by controlling plate and cathode impedances over the entire frequency range of the oscillator. The output stage is protected against a cathode-to-cathode short circuit by the resistors in series with the transformer secondaries. These resistors also make the oscillator present a 600-ohm impedance to the attenuator.

The output stage has sufficient reserve current capacity to avoid overload even if the output terminals are shorted. Capacitors C10, C11, and C12, and coils L2 and L3 are part of the frequency-compensating circuitry.

The output from the cathode-follower stage (1) returns feedback to the frequency-controlling bridge and (2) supplies the primary winding of the output transformers, which couple the oscillator output to the output circuit.

3-4 OUTPUT CIRCUIT

Transformer coupling provides isolation between the oscillator circuit and the output circuit, and allows the output to be obtained either balanced or unbalanced. Since a single transformer will operate suitably over only a part of the frequency range covered by the 200CD, two transformers are provided. Connections between cathode-followers V2 and V4 and the proper transformer for the band in use are set up by the RANGE switch. The secondary windings of the coupling transformers supply a conventional bridged tee attenuator, the setting of which is adjusted by operation of the AMPLITUDE control on the front panel. As the control is turned counterclockwise, the loss inserted by the attenuator is increased. The source impedance at the output terminals is 600 ohms.

With the attenuator set for minimum loss, the output circuit is arranged for balanced operation, and is so designed that for frequencies up to 10 kc, stray capacity and leakage resistance will cause less than 0.1% unbalance. Unbalance at 600 kc is approximately 1%.

When it is desired to operate unbalanced, ground should be connected to the center output terminal, the termination for the connection brought out from terminal 6 of output transformers T1 and T2. Proper operation cannot be obtained if the ground is connected to the side of the circuit which includes the attenuator.

SECTION IV MAINTENANCE

4-1 GENERAL

The maintenance data provided in this section assumes that maintenance personnel are thoroughly familiar with the operating procedures and circuit theory given in Sections II and III, respectively.

The Model 200CD Wide Range Oscillator is designed for long component life and it is probable that tube replacement will correct a majority of the difficulties which may develop. Tube replacement instructions are given in paragraph 4-3.

As a guide in tracing the cause of substandard operation, a trouble-shooting chart is provided in paragraph 4-13.

After locating the source and eliminating the cause of the trouble, the instrument should be tested and adjusted. Performance specifications are given at the front of this manual.

4-2 COVER REMOVAL

On both cabinet and rack models, the cover is fastened to the chassis at the rear with two screws. To remove the cover, remove the screws, and slide the cover off the rear of the instrument.

4-3 TUBE REPLACEMENT

OSCILLATOR

If V1, V2, V3, or V4 is replaced, distortion measurements should be made to determine that distortion in the 200CD output voltage does not exceed the rated 0.5% below 500 kc; less than 1% above 500 kc. Distortion at audio frequencies may be measured with an instrument which directly indicates percent of distortion, such as a Hewlett-Packard Model 330B Noise and Distortion Analyzer.

To determine and correct the probable cause of the distortion, refer to paragraph 4-8.

POWER SUPPLY

Rectifier tube V5 may be replaced with any tube which has corresponding RETMA standard characteristics.

4-4 REPLACEMENT OF LAMPS R13 AND R14

Since lamps R13 and R14 are operated well below rating, they should have an infinite life. However, severe mechanical vibration can damage the lamps.

To check lamp operation, measure the level of the output voltage. It should be 24 volts open circuit or 12 volts into 600 ohms. A vacuum tube voltmeter, such as a Hewlett-Packard Model 410B High Frequency Vacuum Tube Voltmeter, is suitable for making the measurement. Proceed as follows:

- a. Set the Model 200CD on any one of the upper ranges for any frequency above 60 cps; permit a warm-up period of about five minutes.
- b. Turn the AMPLITUDE control maximum clockwise.
- c. Connect the voltmeter to the 600 Ω terminals. The voltmeter indication should be 24 volts open circuit.

If the output voltage is not at the correct level:

- a. Adjust variable resistor R11 (Figure 4-2) to obtain 24 volts.

The screwdriver adjustment for R11 is brought out to the upper side of the deck, and is accessible through the top of the instrument when the cover is off.

- b. If a 24-volt output cannot be obtained by adjustment of R11, replace either or both lamps R13 and R14.

After replacement of the lamps, adjust R11 to obtain 24 volts open circuit.

4-5 REPLACEMENT OF ELECTROLYTIC CAPACITORS

The electrolytic capacitors in this instrument are high quality units which have a useful life of from five to ten years.

4-6 REPLACEMENT OF VARIABLE RESISTORS AND CAPACITORS

VARIABLE RESISTOR R11

After replacement of R11, the level of the output voltage should be measured (see para. 4-4, above), and R11 should be adjusted to obtain an output of 24 volts open circuit or 12 volts across 600 ohms.

VARIABLE RESISTOR R39

Replacement instructions for variable resistor R39 (AMPLITUDE control) are supplied with the replacement control.

VARIABLE CAPACITORS

Variable capacitors C3 and C6 are located on the top of tuning capacitor C5 (Figure 4-2), and variable capacitor C7 is located on the under side of the deck (Figure 4-3).

After replacement of any one of the variable capacitors, check the calibration, paragraph 4-10.

4-7 LUBRICATION, TUNING-CAPACITOR DRIVE MECHANISM

The tuning-capacitor drive mechanism should be lubricated once or twice a year, the interval depending on the amount of use. One drop of light machine oil in each of the holes in the three bearing projections on the back of the casting is sufficient.

4-8 CHECK FOR CAUSE OF DISTORTION

GENERAL

To check for the cause of distortion, the d-c voltage between the cathodes of V2 and V4 should be measured. There should be less than 1 volt between the V2-V4 cathodes, and the voltage read with the RANGE switch on X100 should be the same as that read with the switch on X10. A 20,000 ohms-per-volt, or better (such as a Hewlett-Packard Model 410B), voltmeter may be used for making the measurements. Proceed as follows:

- a. Set the RANGE switch on X10. Turn the frequency dial to "20".

- b. Allow a five minute warm-up period before making the voltage measurements. Connect one terminal of the voltmeter to pin 3 of V2 and the other to pin 3 of V4.

EXCESSIVE GRID CURRENT IN V3

- a. Note the voltmeter reading with the RANGE switch on X10.

- b. Set the RANGE switch on X100, and note the meter reading: if it differs from that obtained with the switch on X10, excessive grid current in V3 is indicated.

- 1) Before replacing V3 with a new 6SH7, interchange V1 and V3, and again measure the voltage between the V2-V4 cathodes with the RANGE switch on X10 and X100.

- 2) If the V1-V3 interchange has not corrected the trouble, replace V3 with another 6SH7.

To determine whether the replacement 6SH7 has the proper characteristics for the oscillator circuit, again measure the distortion.

BAD TUBE IN OSCILLATOR

If more than 1 volt is measured between the V2-V4 cathodes, a bad tube in the oscillator is indicated.

To determine which tube is not operating properly, substitute another tube of corresponding RETMA standard characteristics for each tube in turn. After each tube substitution, measure the distortion.

NOTE

It is recommended that substitution be made first for V1 or V3 since the characteristics of these tubes more greatly affect the purity of the output voltage than do the characteristics of V2 and V4.

4-9 REPLACEMENT OF RANGE SWITCH

GENERAL

The Model 200CD RANGE switch can be replaced as a unit. The replacement is supplied with all the necessary instructions.

4-10 CALIBRATION

The 200CD calibration can be checked and adjusted at any time. A list of equipment and a recommended procedure follows:

EQUIPMENT REQUIRED

- a. Average-responding vacuum tube voltmeter capable of reading down to at least 10 cps, such as Hewlett-Packard Models 400D, 400H, or 400L.
- b. Alignment tool (insulated screwdriver).
- c. A frequency-measuring device:
 - 1) Secondary frequency standard with comparison facilities, such as a Hewlett-Packard Model 100D Secondary Frequency Standard. (If a larger scope pattern than provided by the Model 100D is desired, an external oscilloscope may be used with the Model 100D.) Or:
- d. Frequency counter covering the range up to 600 kc, such as a Hewlett-Packard Model 523B or 524B Electronic Counter.

TERMINOLOGY

When the following expressions are used in this text, they have the meaning here specified.

Slip The Dial:

- 1) Remove center knob on frequency dial.
- 2) Loosen four screws which secure dial plate to drive shaft.
- 3) Reset dial to position indicated in text.
- 4) Tighten four securing screws. (Center knob may be replaced at end of procedure.)

On Calibration:

Frequency indication centered beneath dial indicator index is the same as output frequency.

CONNECTIONS

Connection arrangements are indicated in Figure 4-1. Connect as follows:

- a. 600-ohm load across Model 200CD output.
- b. Output of Model 200CD to input of measuring equipment.

CALIBRATION PROCEDURE

- a. Turn on Model 200CD; allow at least 30 minute warm-up period. Remove cover from Model 200CD.
- b. Set RANGE switch on X10. Turn dial to "5".
 - 1) If Model 200CD not on calibration at "5", slip dial, and put "5" on calibration.

2) Set voltage reference, for example 9 volts. (Adjust AMPLITUDE control to get voltmeter indication of 9 volts.)

- c. Turn frequency dial toward high end to find where 600 cps falls at top of X10 range. If 600 cps on X10 range does not fall at "60":
 - 1) Turn dial to "60".

2) With alignment tool, adjust either trimmer (C3 or C6 [Figure 4-2]) to bring "60" on calibration. (Seldom necessary to adjust both trimmers.)

- 3) Note output voltage. If not 9 volts:
 - (a) Correct for half of voltage error with trimmer adjusted in step 2.
 - (b) Adjust other trimmer to correct frequency error.

d. Repeat steps b and c until calibration is on and output is 9 volts at both "5" and "60".

e. Set RANGE switch at X100. Check tracking across range; if not within specifications, proceed as explained in paragraph 4-11.

f. Check "5" and "60" points on X10K, X1K, and X1 ranges.

1) Except for high end of X10K range, the X1, X10, X100, X1K, and X10K ranges should be within specifications.

2) If "60" on X10K range not on calibration, adjust C7 (Figure 4-3).

4-11 TRACKING ADJUSTMENTS**HIGH END OF RANGE**

a. Set RANGE switch on X100.

b. Slip dial to set "20" right on calibration.

c. Turn frequency dial to "5", and adjust AMP-LITUDE control to obtain output of 9 volts.

d. Turn frequency dial to "60".

1) If "60" not on calibration, adjust either trimmer (C3 or C6) until "60" is on calibration.

2) Check output voltage. If not 9 volts:

- (a) Correct for half of voltage error with one trimmer adjusted in step 1.
- (b) Correct frequency error with other trimmer.

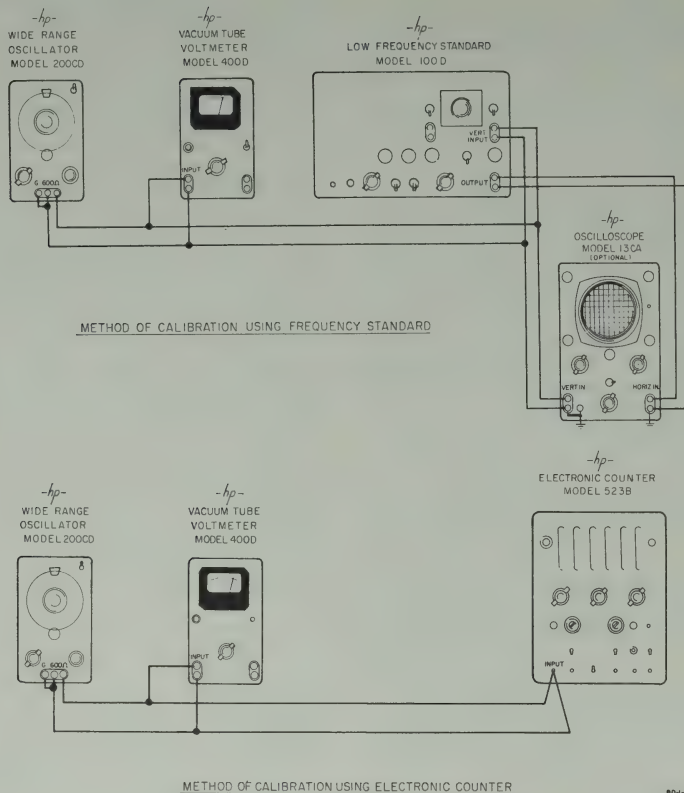


Figure 4-1. Model 200CD Calibration Procedure Equipment Arrangement

- e. Repeat steps c and d until calibration is on at "60" and output is 9 volts at both "5" and "60".

To raise the frequency of oscillation, spread plates.
To lower the frequency, squeeze plates.

High end of dial will now track within specifications.

LOW END OF RANGE

- Check rest of dial, and find which cardinal points are off calibration. Leave RANGE switch at X100.
- For each point outside of specifications, bend associated tuning-capacitor plates to bring point within specifications.

The bending operation must always start with highest-frequency point involved. For example, if calibration is off at "7", "6", and "5", start bending at plates associated with "7".

4-12 POWER TRANSFORMER PRIMARY CONNECTIONS

Connections to the primary winding of power transformer T3 are brought out to a terminal strip (identified in Figure 4-3) mounted on the right side of the instrument.

The power transformer primaries of the Model 200CD are connected for 115-volt operation at the factory. If the instrument is to be operated from a 230-volt power source:

- a. Reconnect the T3 primaries for 230-volt operation, as indicated on the schematic diagram.
- b. Replace a 1-ampere fuse F1 with a 1/2 ampere fuse of the type specified in the Table of Replaceable Parts.

sociated with referenced tubes also are failure possibilities. Within each section of the chart, checking should be performed in the order given since it is assumed throughout a procedure that the parts checked previously are functioning correctly.

When testing the Model 200CD, it is recommended that line voltage be applied to the instrument through a variable transformer, and that the transformer be adjusted to deliver a voltage at the low end of the rated 105- to 125-volt range. An instrument in good condition operates satisfactorily from any line voltage within rated range, but where there is marginal operation (from weak tubes, etc.) weaknesses become easier to trace at low line voltages.

4-13 TROUBLE SHOOTING CHART

The following chart lists various symptoms of trouble and for each indicates the part or parts of the circuit which should be checked. In the main, for purposes of simplification, only the tubes are referenced, but it should be remembered that components as-

TROUBLE SHOOTING CHART

SYMPTOM AND POSSIBLE CAUSE	TEST PROCEDURE	REMEDY
1. Instrument NOT operating; index window NOT lighted.		
a. Fuse open due to defective fuse or overload in power supply.	a. Replace fuse. If new fuse blows, remove V5 and replace fuse. (1) Blowing of 2nd fuse indicates: A. Short circuit in wiring associated with T3. B. Short circuit in filament wiring. C. Defective transformer T3. (2) No opening of 2nd fuse with V5 removed indicates: A. Defective rectifier V5. B. Internal short circuit in V1, V2, V3, or V4. C. Short circuit in d-c wiring. D. Defective C13ABC. D-c resistance from pin 8 of V5 to ground normally is approximately 5 megohms; disconnect line voltage before measuring.	A. Locate and clear short. B. Locate and clear short. C. Replace transformer. A. Replace V5. B. Locate and replace defective tube. C. Locate and clear short. D. If defective, replace C13.
b. Poor connection to line voltage.	b. Check power cable, and connections at both ends of cable.	
2. Instrument NOT operating; index window lighted.		
a. Power supply not operating properly.	a. Check level of d-c voltage at power supply output; should be $325V \pm 10\%$. Use d-c voltmeter such as Model 410B; connect voltmeter + terminal to terminal 3 or 4 on capacitor C13, and voltmeter-terminal to C13 terminal 1. If voltmeter indication not $325V \pm 10\%$, check rectifier tube V5, and then other components of power supply.	a. Replace defective component.
b. Defective tube in oscillator circuit.	b. Check for bad V1, V2, V3, or V4 by substituting tube of same type known to be good.	b. Replace defective tube. See paragraph 4-3.

TROUBLE SHOOTING CHART (Continued)

SYMPTOM AND POSSIBLE CAUSE	TEST PROCEDURE	REMEDY
<p>c. Short circuit in tuning capacitor C5, variable capacitor C3 or C6 or fixed capacitor C4.</p> <p>d. Capacitor C5 shorted to ground.</p> <p>e. Defective lamp (R13 or R14).</p>	<p>c. (1) To check capacitors C5A, C5B, C3, and C4: A. Disconnect Model 200CD from line. B. Connect one ohmmeter terminal to C5 terminal designated C5B on Figure 4-2, and other to chassis. C. Turn RANGE switch to X1. D. Ohmmeter should indicate approximately 25.79M.</p> <p>(2) To check capacitors C5C, C6: A. Connect one ohmmeter terminal to C5 common terminal (Figure 4-2) and other to chassis. B. With 200CD disconnected from line and RANGE switch on X1, ohmmeter should indicate approximately 50.18M.</p> <p>d. (1) Connect one ohmmeter terminal to C5 terminal (designated C5C on Figure 4-2), and other to chassis. (2) With 200CD disconnected from line and RANGE switch at any setting, ohmmeter should indicate approximately 10K.</p> <p>e. See paragraph 4-4.</p>	<p>c. If resistance measurements indicate short, before making further checks, visually examine C5. If C5 is dirty, gently blow dust from plates with air hose, and then again make resistance measurements.</p> <p>d. If resistance measurement indicates short, check for defect in insulation between C5 and instrument chassis.</p>
<p>3. Instrument operating properly on only part of the range.</p> <p>a. Dirty contacts on RANGE.</p> <p>b. Open RANGE switch resistor.</p>	<p>a. Examine all sections of RANGE switch for dirty contacts.</p> <p>b. Check resistors associated with affected range.</p>	<p>a. Contacts may be cleaned with E-Z Aid or other silver dip.</p> <p>b. Replace resistor or RANGE switch. See paragraphs 4-9 and 4-10.</p>
<p>4. Instrument operating properly on X1K, X10K; not operating properly on X1, X10, X100.</p> <p>a. Dirty contacts on RANGE switch.</p> <p>b. Defect in transformer T2.</p>	<p>a. Examine RANGE switch contacts for dirt, particularly in sections SIC, D, E, F, G, H. Sections SIC, D, E, F are on wafer ahead of transformer shield, sections SIG, H are on wafer behind shield.</p> <p>b. Check T2.</p>	<p>a. Contact may be cleaned with E-Z Aid or other silver dip.</p> <p>b. Replace T2 if defective.</p>

TROUBLE SHOOTING CHART (Continued)

SYMPTOM AND POSSIBLE CAUSE	TEST PROCEDURE	REMEDY
<p>5. Instrument operating properly on X1, X10, X100; not operating properly on X1K, X10K.</p> <p>a. Dirty contacts on RANGE switch.</p> <p>b. Defect in transformer T1.</p>	<p>a. Examine RANGE switch contacts for dirt, particularly in sections SIC, D, E, F, G, H.</p> <p>b. Check T1.</p>	<p>a. Contacts may be cleaned with E-Z Aid or other silver dip.</p> <p>b. Replace T1 if defective.</p>
<p>6. Distortion in output.</p> <p>a. Bad tube in oscillator circuit.</p> <p>b. Incorrect potentials on tube pins.</p> <p>c. Dust on plates of tuning capacitor C5.</p> <p>d. Defective lamp (R13 or R14).</p>	<p>a. See paragraphs 4-3 and 4-8.</p> <p>b. (1) Check as described in 2a, above.</p> <p>(2) Check d-c voltage on pins of all tube sockets; except as noted in Figure 4-6, voltages should be within $\pm 10\%$ of values shown in schematic or Figure 4-6.</p> <p>c. Inspect visually.</p> <p>d. See paragraph 4-4.</p>	<p>(1) Replace defective tube. See paragraph 4-3.</p> <p>(2) If potential on any pin not correct value, check resistors in power-supply network associated with incorrect potential.</p> <p>c. With air hose, gently blow out dust.</p>
<p>7. Noise present in output waveform when AMPLITUDE control is rotated; output voltage unstable when AMP-LITUDE control is rotated.</p> <p>a. Defective AMP-LITUDE control (R39).</p>		<p>a. Replace R39 (see paragraph 4-6).</p>

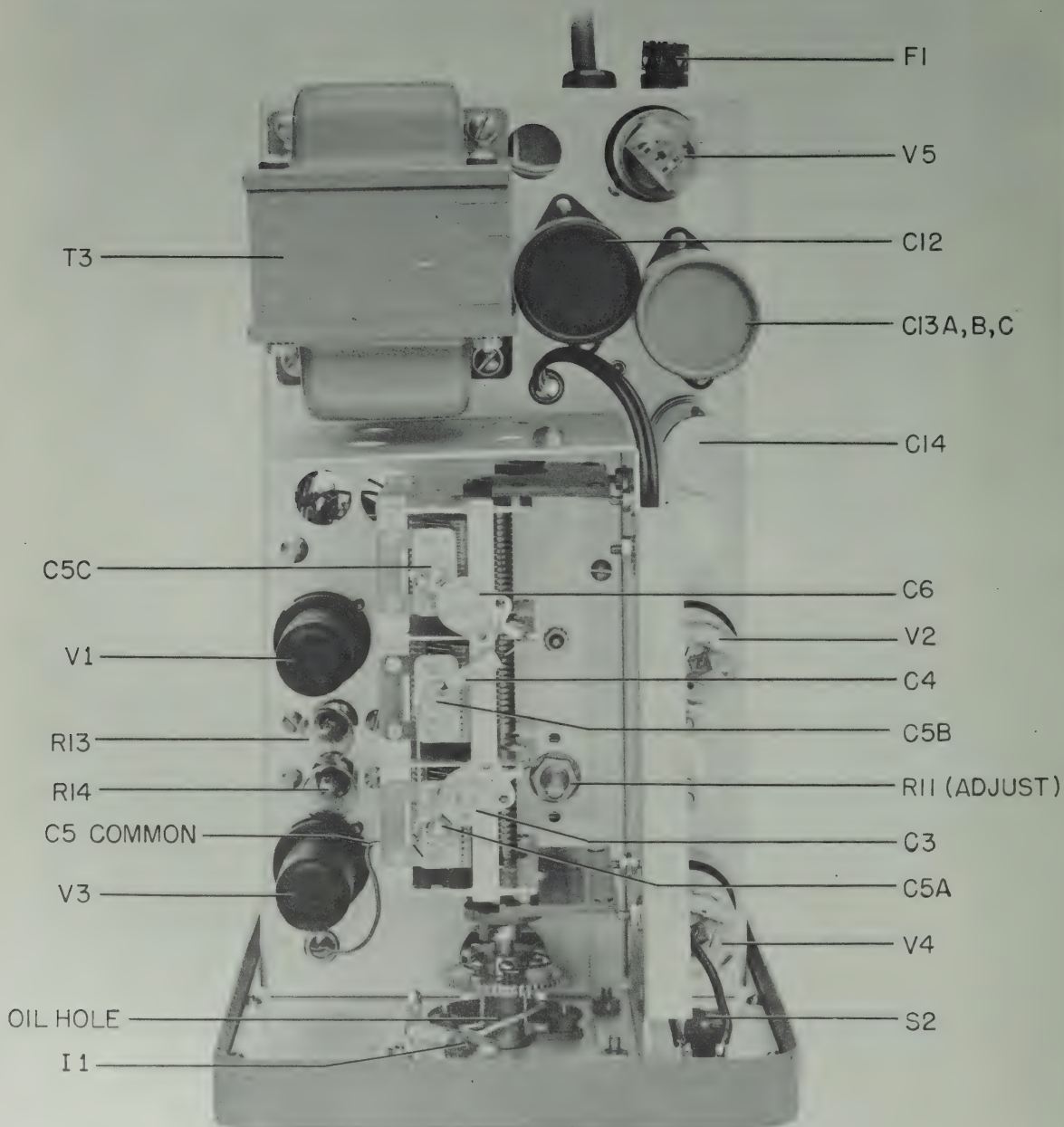


Figure 4-2 Model 200CD Top View Cover Removed

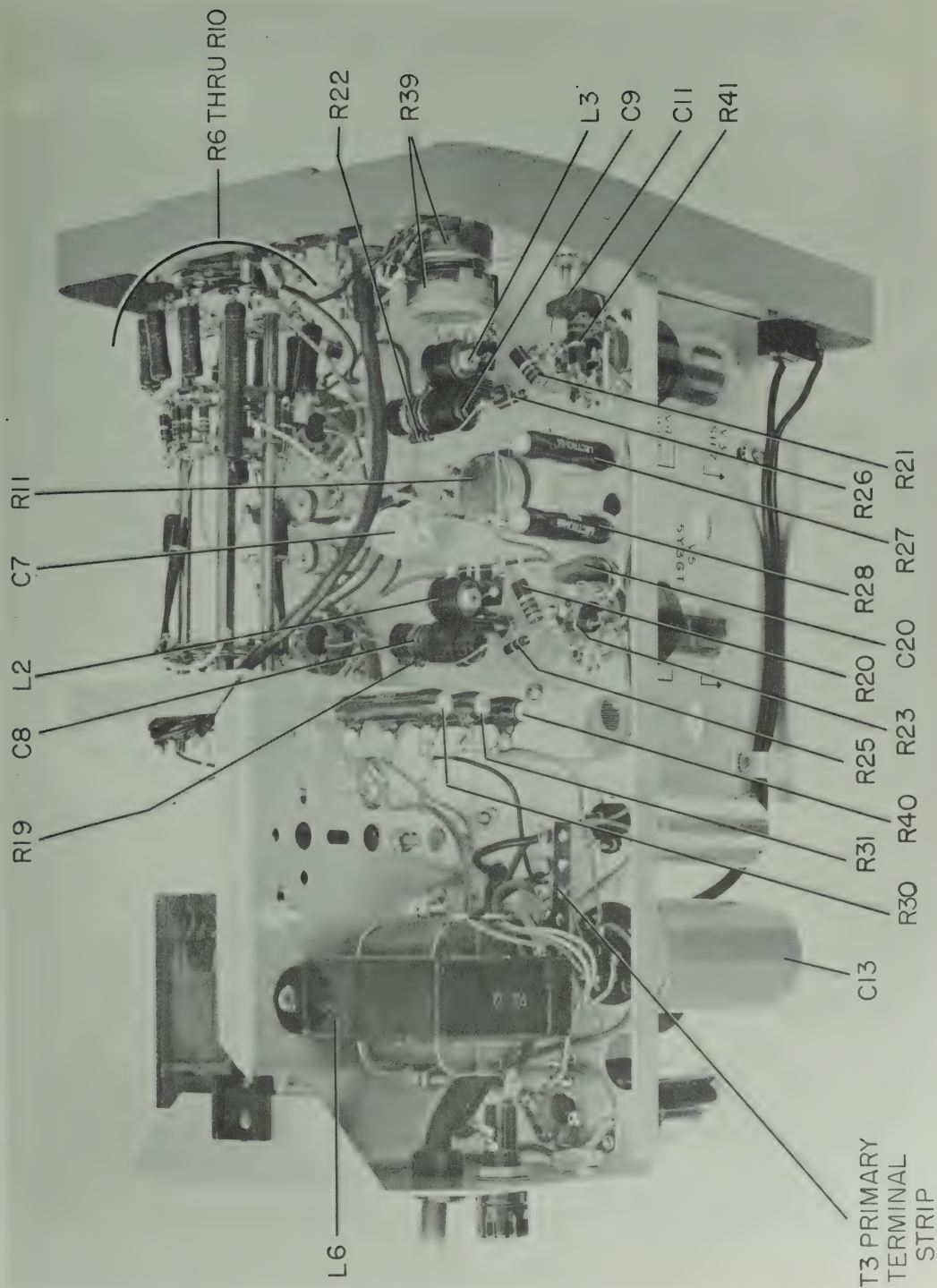


Figure 4-3 Model 200CD View of Right Side Bottom Side Up

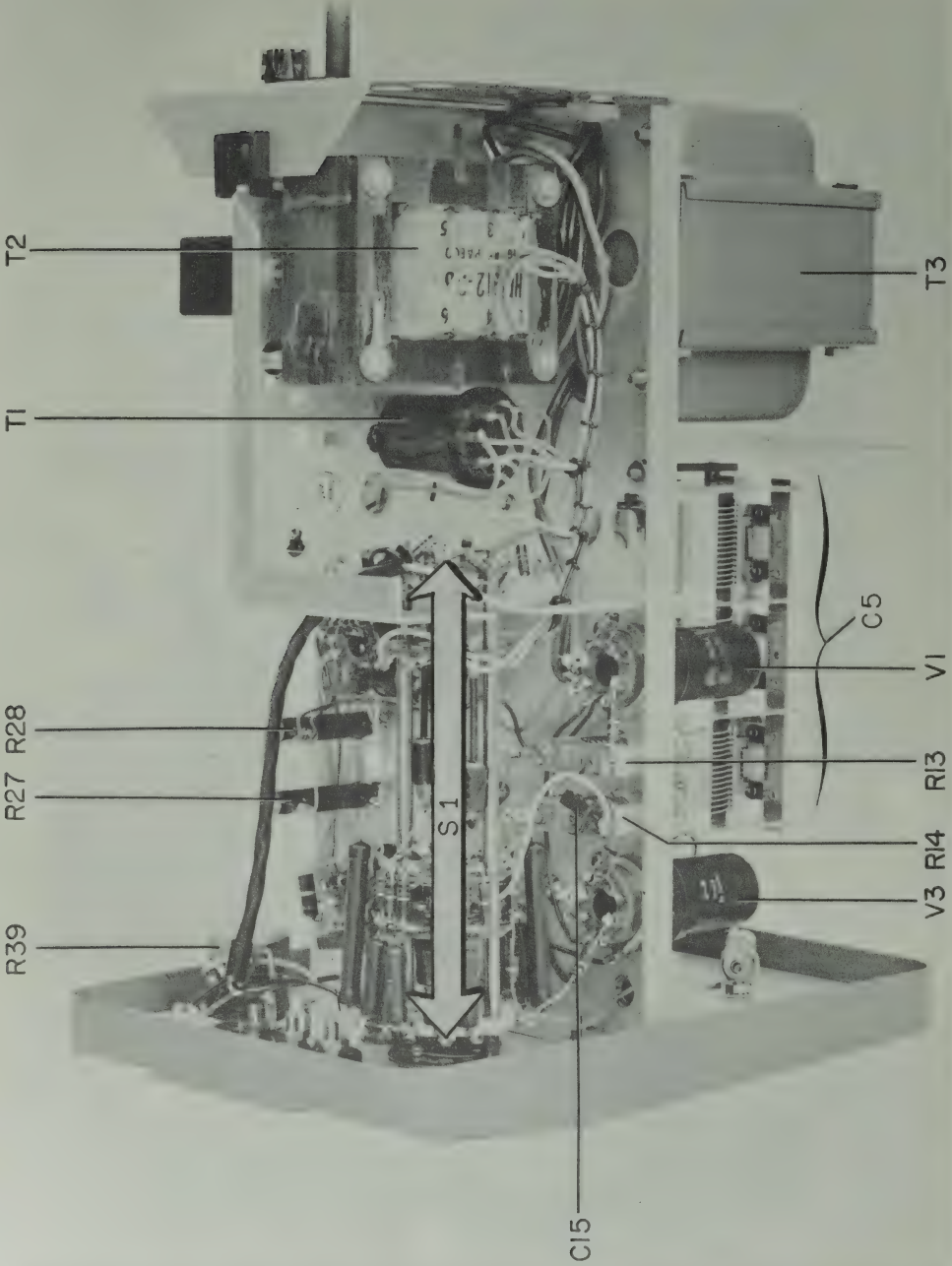


Figure 4-4 Model 200CD View of Left Side Bottom Side Up

NOTES:

- CONDITIONS OF DC VOLTAGE MEASUREMENT
 1. BETWEEN INDICATED POINT AND CHASSIS WITH
 VOLT-METER OF 122 MEGOHMS INPUT RESISTANCE
 2. LINE VOLTAGE 115/230 VOLTS, 50-1000 \sim
 3. AMPLITUDE CONTROL AT ZERO
 4. RANGE SWITCH AT X100
 5. FREQUENCY DIAL AT "10"

- CONDITIONS OF RESISTANCE MEASUREMENT
 1. BETWEEN INDICATED POINT AND CHASSIS WITH
 OHMMETER

2. DISCONNECTED FROM LINE VOLTAGE
 3. CAPACITORS CHARGED BY OHMMETER BEFORE
 READINGS TAKEN

DNA = RESISTANCE MEASUREMENT IMPRACTICAL DUE
 TO HIGH CAPACITANCE IN PARALLEL WITH HIGH
 RESISTANCE TO GROUND, VALUE IN PARENTHESES
 APPROXIMATE

- CONDITIONS OF AC VOLTAGE MEASUREMENT
 1. BETWEEN INDICATED POINT AND NEGATIVE BUS

* = VOLTAGE MAY VARY UP TO $\pm 20\%$

** = TIE POINT

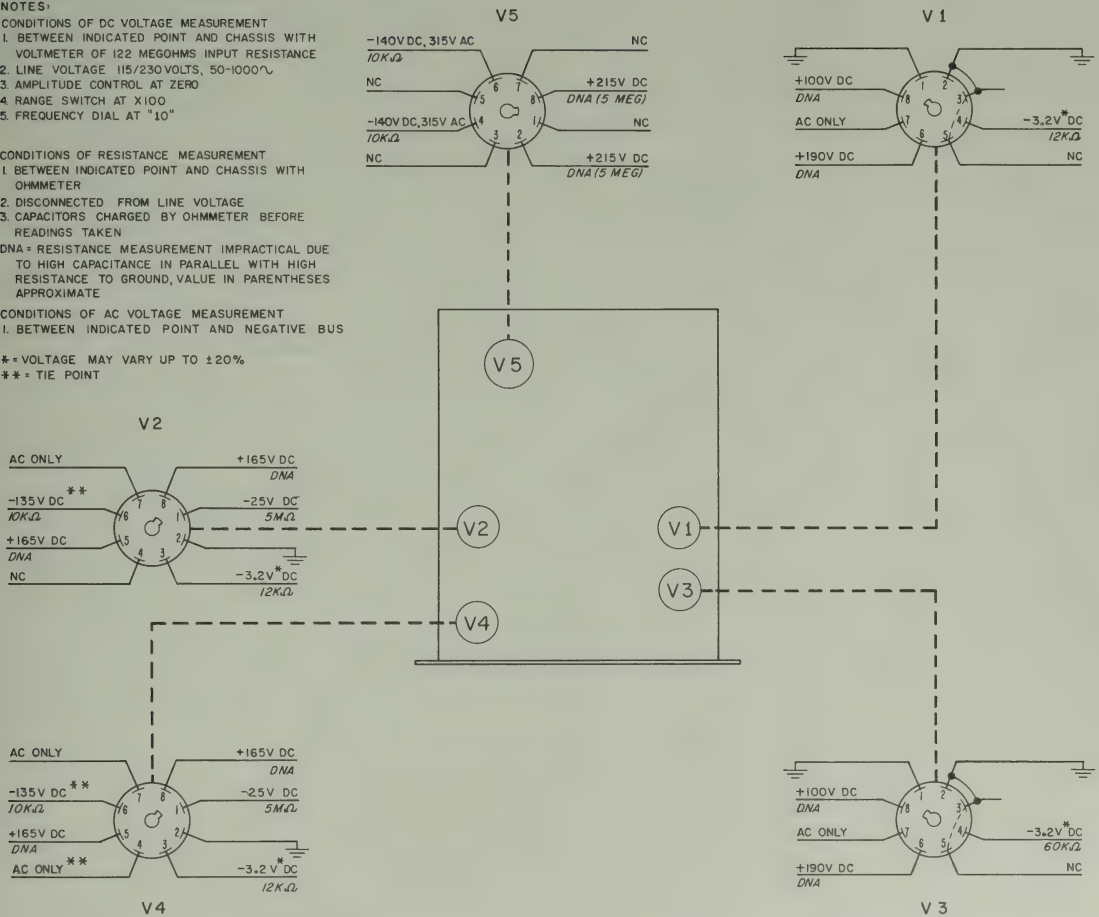


Figure 4-5. Model 200CD Tube Socket Voltage-Resistance Diagram

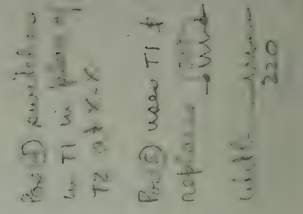
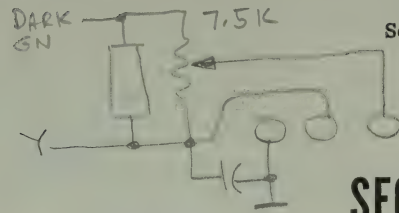
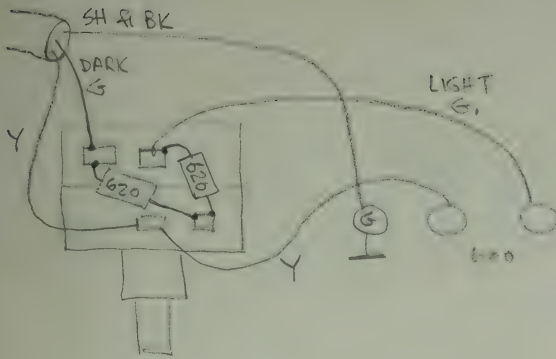


Figure 4-6. Model 200CD Wide Range Oscillator

A/25/81



Sect. V Page 1

SECTION V TABLE OF REPLACEABLE PARTS

NOTE

Any changes in the Table of Replaceable Parts will be listed on a Production Change sheet at the front of this manual.

When ordering parts from the factory always include the following information:

Instrument Model Number

Serial Number

Ⓢ Stock Number of Part

Description of Part

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	#			
C1	Capacitor: fixed, ceramic, 10 μf , $\pm 5\%$ μf , 500 vdcw Electrical value adjusted at factory K*	15-30	1			
C2	Capacitor: fixed, titanium dioxide, 1 μf , $\pm 10\%$, 500 vdcw Electrical value adjusted at factory DD*	15-102	1			
C3	Capacitor: variable, ceramic 7-45 μf , 500 vdcw L*	13-1	1			
C4	Capacitor: fixed, ceramic, 39 μf , $\pm 5\%$, 500 vdcw K*	15-4	1			
C5	Capacitor: variable, 3 sections, 600 μf /sect. W*	12-28	1			
C6	Same as C3					
C7	Capacitor: variable, ceramic, 1.5-7 μf , 500 vdcw L*	13-7	1			
C8, 9	Capacitor: fixed, paper, .047 μf , $\pm 10\%$, 600 vdcw CC*	16-15	2			
C10, 11	Capacitor: fixed, mica, 100 μf , $\pm 10\%$, 500 vdcw V*	14-100	2			
C12	Capacitor: fixed, electrolytic, 100 μf , 100 vdcw CC*	18-25HP	1			
C13 A, B, C	Capacitor: fixed, electrolytic, 3 sections, 10 μf /sect., 450 vdcw CC*	18-31HP	1			
C14	Capacitor: fixed, electrolytic, 40 μf , 450 vdcw CC*	18-40HP	1			
C15	Capacitor: fixed, mica, 22 μf , $\pm 10\%$, 300 vdcw Electrical value adjusted at factory V*	14-69	1			
C16	Capacitor: fixed, titanium dioxide, 3.3 μf , $\pm 10\%$, 500 vdcw Electrical value adjusted at factory DD*	15-78	1			
C17, 18	Capacitor: fixed, mica, 27 μf , $\pm 10\%$, 500 vdcw Electrical value adjusted at factory V*	14-17	2			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	#			
F1	Fuse, cartridge: 1 amp, 115V operation or Fuse, cartridge: 1/2 amp, 230V operation	E* E*	211-18 211-20	1		
I1	Lamp, incandescent: 6-8V, .15 amp, #47	N*	211-47	1		
L1	This circuit reference not assigned					
L2, 3	Reactor, R. F., coil, 2.0 MH	HP*	200CD- 60C	2		
L4, 5	Coil, R. F., filter, 25 μ h	HP*	200CD- 60B	2		
L6	Reactor: filter, choke, 240 ohms	Paeco	911-12	1		
P1	Power Cord	Elec. Cords Co.	812-56	1		
R1	Resistor: fixed, deposited carbon, 2450 ohms, $\pm 1\%$, 1 W	NN*	31-2450	1		
R2	Resistor: fixed, deposited carbon, 24,500 ohms, $\pm 1\%$, 1 W	NN*	31-24.5K	1		
R3	Resistor: fixed, deposited carbon, 245,000 ohms, $\pm 1\%$, 1 W	NN*	31-245K	1		
R4	Resistor: fixed, deposited carbon, 2.45 megohms, $\pm 1\%$, 1 W	NN*	31-2.45M	1		
R5	Resistor: fixed, deposited carbon, 24.5 megohms, $\pm 1\%$, 2 W	NN*	32-24.5M	1		
R6	Resistor: fixed, deposited carbon, 49 megohms, $\pm 1\%$, 2 W	NN*	32-49M	1		
R7	Resistor: fixed, deposited carbon, 4.9 megohms, $\pm 1\%$, 1 W	NN*	31-4.9M	1		
R8	Resistor: fixed, deposited carbon, 490,000 ohms, $\pm 1\%$, 1 W	NN*	31-490K	1		
R9	Resistor: fixed, deposited carbon, 49,000 ohms, $\pm 1\%$, 1W	NN*	31-49K	1		
R10	Resistor: fixed, deposited carbon, 4900 ohms, $\pm 1\%$, 1 W	NN*	31-4900	1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#			
R11	Resistor: variable, composition, 1000 ohms, $\pm 20\%$, 1/2 W G*	210-51	1			
R12	Resistor: fixed, composition, 3000 ohms, $\pm 5\%$, 1 W B*	24- 3000-5	1			
R13, 14	Lamp, incandescent: 250V, 10W N*	211-29	2			
R15, 16	Resistor: fixed, composition, 56 ohms, $\pm 10\%$, 1/2 W B*	23-56	2			
R17, 18	Resistor: fixed, composition, 22,000 ohms, $\pm 10\%$, 1 W B*	24-22K	2			
R19	Resistor: fixed, composition, 10 megohms, $\pm 5\%$, 1/2 W B*	23- 10M-5	1			
R20, 21	Resistor: fixed, composition, 68,000 ohms, $\pm 10\%$, 1 W B*	24-68K	2			
R22	Same as R19					
R23, 24	Resistor: fixed, composition, matched pair, 8.2 megohms, 1/2 W HP*	200CD- 67	1			
R25, 26	Same as R15					
R27, 28	Resistor: fixed, wirewound, 500 ohms, $\pm 10\%$, 10 W S*	26-5	2			
R29	Resistor: 470 ohms, part of L4					
R30, 31	Resistor: fixed, matched pair, 2500 ohms HP*	200J- 26	1			
R32	Resistor: 470 ohms, part of L5					
R33, 34	Resistor: fixed, composition, 300 ohms, $\pm 5\%$, 1/2 W B*	23- 300-5	2			
R35, 36	These circuit references not assigned					
R37, 38	Resistor: fixed, composition, 200 ohms, $\pm 5\%$, 1/2 W B*	23-200- 5	2			
R39 A, B	Output Attenuator Assembly: 600 ohm delta "T", includes R46 and 47. HP*	200CD- 34	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	Ⓢ STOCK NO.	#			
R40	Resistor: fixed, wirewound, 10,000 ohms, $\pm 10\%$, 10 W S*	26-10	1			
R41	Resistor: fixed, composition, 18 ohms, $\pm 10\%$, 1 W B*	24-18	1			
R42, 43	Resistor: fixed, composition, 220 ohms, $\pm 10\%$, 1 W B*	24-220	2			
R44, 45	Resistor: fixed, composition, 240 ohms, $\pm 5\%$, 1/2 W B*	23-240-5	2			
R46, 47	Resistor: fixed, composition, 620 ohms, $\pm 5\%$, 1/2 W part of Output Attenuator Assembly B*	23-620-5	2			
S1	Range Switch Assembly HP*	200CD- 19WB	1			
S2	Switch, toggle: SPST D*	310-11	1			
T1	Transformer, output: high frequency HP*	200CD- 9	1			
T2	Transformer, output: low frequency Paeco	912-38	1			
T3	Transformer, power Paeco	910-94	1			
V1	Tube, electron: 6SH7 ZZ*	G-73AB	2			
	Tubes selected for best performance will supplied by Ⓢ (if ordered by Ⓢ Stock No.) but tubes meeting RETMA standards will normally result in the instrument operating within specifications.					
V2	Tube, electron: 6AU5GT ZZ*	212- 6AU5GT	2			
V3	Same as V1					
V4	Same as V2					
V5	Tube, electron: 5Y3GT ZZ*	212- 5Y3GT	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

Total quantity used in the instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	STOCK NO.	#			
	MISCELLANEOUS					
	Binding Post Assembly: ground with link HP*	G-76J	1			
	Binding Post Assembly: red HP*	AC-10D	2			
	Coupler, insulated HP*	AC-32A	1			
	Disc, vernier drive on shaft HP*	G-14A	1			
	Disc, vernier drive HP*	G-14B	1			
	Fuseholder T*	140-16	1			
	Insulator, binding post: black HP*	AC-54B	1			
	Knob: AMPLITUDE HP*	G-74K	1			
	Knob: RANGE HP*	G-74N	1			
	Knob: frequency dial vernier HP*	G-74F	1			
	Knob: frequency dial HP*	G-74Z	1			
	Spring, compression, for vernier drive Connor Spring Co.	146-23	1			
	Window, dial for curved frequency dial HP*	G-99K	1			

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

Total quantity used in the instrument.

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS	CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.	AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
B	Allen-Bradley Co.	Milwaukee 4, Wis.	AL	Industrial Condenser Corp.	Chicago 18, Ill.
C	Amperite Co.	New York, N. Y.	AM	Insuline Corp. of America	Manchester, N. H.
D	Arrow, Hart & Hegeman	Hartford, Conn.	AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
E	Bussman Manufacturing Co.	St. Louis, Mo.	AO	E. F. Johnson Co.	Waseca, Minn.
F	Carborundum Co.	Niagara Falls, N. Y.	AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
G	Centralab	Milwaukee 1, Wis.	AQ	Micro-Switch	Freeport, Ill.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.	AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
HP	Hewlett-Packard Co.	Palo Alto, Calif.	AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
I	Clarostat Mfg. Co.	Dover, N. H.	AT	The Muter Co.	Chicago 5, Ill.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.	AU	Ohmite Mfg. Co.	Skokie, Ill.
K	Hi-Q Division of Aerovox	Olean, N. Y.	AV	Resistance Products Co.	Harrisburg, Pa.
L	Erie Resistor Corp.	Erie 6, Pa.	AW	Radio Condenser Co.	Camden 3, N. J.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.	AX	Shallcross Manufacturing Co.	Collingdale, Pa.
N	General Electric Co.	Schenectady 5, N. Y.	AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
O	General Electric Supply Corp.	San Francisco, Calif.	AZ	Sealectro Corp.	New Rochelle, N. Y.
P	Girard-Hopkins	Oakland, Calif.	BA	Spencer Thermostat	Attleboro, Mass.
Q	Industrial Products Co.	Danbury, Conn.	BC	Stevens Manufacturing Co.	Mansfield, Ohio
R	International Resistance Co.	Philadelphia 8, Pa.	BD	Torrington Manufacturing Co.	Van Nuys, Calif.
S	Lectrohm Inc.	Chicago 20, Ill.	BE	Vector Electronic Co.	Los Angeles 65, Calif.
T	Maglufuse Inc.	Des Plaines, Ill.	BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
U	Maguire Industries Inc.	Greenwich, Conn.	BG	Advance Electric & Relay Co.	Burbank, Calif.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.	BH	E. I. DuPont	San Francisco, Calif.
W	Oak Manufacturing Co.	Chicago 10, Ill.	BI	Electronics Tube Corp.	Philadelphia 18, Pa.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.	BJ	Aircraft Radio Corp.	Boonton, N. J.
Y	Radio Corp. of America	Harrison, N. J.	BK	Allied Control Co., Inc.	New York 21, N. Y.
Z	Sangamo Electric Co.	Marion, Ill.	BL	Augat Brothers, Inc.	Attleboro, Mass.
AA	Sarkes Tarzan	Bloomington, Ind.	BM	Carter Radio Division	Chicago, Ill.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.	BN	CBS Hytron Radio & Electric	Danvers, Mass.
CC	Sprague Electric Co.	North Adams, Mass.	BO	Chicago Telephone Supply	Elkhart, Ind.
DD	Stackpole Carbon Co.	St. Marys, Pa.	BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
EE	Sylvania Electric Products Co.	Warren, Pa.	BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
FF	Western Electric Co.	New York 5, N. Y.	BR	Allen B. DuMont Labs	Clifton, N. J.
GG	Wilkor Products, Inc.	Cleveland, Ohio	BS	Excel Transformer Co.	Oakland, Calif.
HH	Amphenol	Chicago 50, Ill.	BT	General Radio Co.	Cambridge 39, Mass.
II	Dial Light Co. of America	Brooklyn 37, N. Y.	BU	Hughes Aircraft Co.	Culver City, Calif.
JJ	Leecraft Manufacturing Co.	New York, N. Y.	BV	International Rectifier Corp.	El Segundo, Calif.
KK	Switchcraft, Inc.	Chicago 22, Ill.	BW	James Knights Co.	Sandwich, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.	BX	Mueller Electric Co.	Cleveland, Ohio
MM	Carad Corp.	Redwood City, Calif.	BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
NN	Electra Manufacturing Co.	Kansas City, Mo.	BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
OO	Acro Manufacturing Co.	Columbus 16, Ohio	CA	Raytheon Manufacturing Co.	Newton, Mass.
PP	Alliance Manufacturing Co.	Alliance, Ohio	CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
QQ	Arco Electronics, Inc.	New York 13, N. Y.	CD	Varian Associates	Palo Alto, Calif.
RR	Astron Corp.	East Newark, N. J.	CE	Victory Engineering Corp.	Union, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.	CF	Weckesser Co.	Chicago 30, Ill.
TT	Belden Manufacturing Co.	Chicago 44, Ill.	CG	Wilco Corporation	Indianapolis, Ind.
UU	Bird Electronics Corp.	Cleveland 14, Ohio	CH	Winchester Electronics, Inc.	Santa Monica, Calif.
VV	Barber Colman Co.	Rockford, Ill.	CJ	Malco Tool & Die	Los Angeles 42, Calif.
WW	Bud Radio Inc.	Cleveland 3, Ohio	CI	Oxford Electric Corp.	Chicago 15, Ill.
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.	CK	Camloc-Fastener Corp.	Paramus, N. J.
YY	Cinema Engineering Co.	Burbank, Calif.	CL	George K. Garrett	Philadelphia 34, Pa.
ZZ	Any brand tube meeting RETMA standards.		CM	Union Switch & Signal	Swissvale, Pa.
AB	Corning Glass Works	Corning, N. Y.	CN	Radio Receptor	New York 11, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.	CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
AD	The Drake Mfg. Co.	Chicago 22, Ill.	CP	Bassick Co.	Bridgeport 2, Conn.
AE	Elco Corp.	Philadelphia 24, Pa.	CQ	Birnbach Radio Co.	New York 13, N. Y.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.	CR	Fischer Specialties	Cincinnati 6, Ohio
AG	Thomas A. Edison, Inc.	West Orange, N. J.	CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.	CT	Potter-Brumfield Co.	Princeton, Ind.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.	CU	Cannon Electric Co.	Los Angeles, Calif.
AJ	The Gudeman Co.	Sunnyvale, Calif.	CV	Dynac, Inc.	Palo Alto, Calif.
			CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

